SCIENTIFIC INDUSTRIES

EXPLAINED

SHOWING HOW SOME OF THE IMPORTANT
ARTICLES OF COMMERCE ARE MADE

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ANILINE COLOURS.	ALKALIES.
PIGMENTS.	PHOSPHORUS.
SOAP-MAKING.	BLEACHING POWDER.
CANDLE-MAKING.	INKS.
PAPER-MAKING.	VINEGAR-MAKING.
GUNPOWDER.	ACETIC ACID
GLASS.	FIREWORKS—COLOURED
ALCOHOL.	FIRES.
BEER.	GUN-COTTON.
ACIDS.	DISTILLATION.

ETC. ETC. ETC.

PREFACE.

" Knowledge is power."

ACCUSTOMED as we are to behold the marvellous applications of Science to the useful purposes of everyday life, how few of us take the trouble to inquire how this or that effect is produced which adds so much to our comfort, our enjoyment, and our wealth! We delight in clean linen, but know not how soap is made; we admire the varied hues of our clothing and our finery, but are ignorant of the processes by which such charming tints are obtained; we know that the prosperity of our country depends greatly upon our success in certain manufactures, but alas, how little we know of the thought, care, and which are involved in their production, or of the m by which the various results are obtained!

To give an insight into the Scientific Industries of our country, in a simple and easily understood form, is the object of the present work; and it has been the Author's aim to instruct without tiring his reader with elaborate details. A systematic arrangement of the subjects treated has been purposely avoided, in order that the work may be regarded as a means of intellectual recreation rather than a severe study.

ANILINE COLOURS—PHILOSOPHY OF A LUMP OF COAL.

We all know that our streets and homes are illumined by gas, that this gas is obtained from coal, and that coke and gas-tar come from the gasworks; but here ends, generally speaking, our knowledge of the remarkable product of Nature called coal, if we simply include its employment in our fire-stoves.

But there is a great deal more to be said about coal after the gasworks have done with it than most people are aware of, and this it will be our pleasing task to illustrate as simply as the subject will admit.

When coal is placed in an iron retort, and heat applied, after a while its gaseous and volatile constituents become liberated, and coke alone remains behind. Now if we connect a tube to the upper part of the retort, through which these volatile matters may pass, and allow the end of the tube to dip into a vessel of water, we shall find that bubbles of gas escape from the tube, while the water has become impregnated with ammonia; and after a while a dark mass appears at the bottom of the vessel. This latter substance is called "coal-tar," with which we have now more especially to deal, since it forms the basis of our present study.

Now if we place a quantity of coal-tar in a retort furnished with a tube, terminating in a "worm" surrounded

by cold water, as in distilling, and heat the retort gradually
we soon find that a fluid substance, having a powerful
odour, escapes through the worm-pipe, which we collect
in a receiver. This liquid is "coal-tar naphtha," and is
composed of many different substances, all more or less
inflammable, the lightest and most volatile product being
benzole. If the coal-tar naphtha be now placed in a retort
fitted with a receiver, and heat applied below 200° Fahr
—that is, *below* the boiling-point of water—a light spirit
distils over which is termed *benzole*.

When fuming nitric acid is added to benzole, violent
chemical action takes place, and the resulting compound
is called *nitro-benzole*. If water be now added, the nitro-
benzole deposits at the bottom of the vessel in the form of
a thick oily mass somewhat like the yolk of an egg. To
convert the nitro-benzole into *aniline* we proceed as
follows: The nitro-benzole is placed in a glass or stone-
ware retort, and iron filings and acetic acid added in the
proportion of two parts of the former to one part of the
latter to an equal volume of the nitro-benzole. Efferves-
cence takes place, and aniline, a colourless fluid, distils
over into the receiver. When the effervescence ceases,
gentle heat is applied to assist the operation.

Having thus obtained our aniline, we next proceed to
treat it with various chemical substances, when remarkable
—indeed marvellous—changes are effected, as we shall
presently see. When bichloride of mercury, bichloride
of tin, and certain other chemical salts are mixed with
aniline, a compound is formed which has been termed
rosaniline. When dry, it appears in the form of beautiful
green crystals having a somewhat metallic lustre, not
unlike the wings of the common "May bug," a beetle

requently seen in our rose-bushes. When these green crystals are placed in hot water, or in spirit of wine, a gorgeous red-coloured solution is the result. Now there is nothing whatever in the appearance of these green crystals, or in the process by which they were formed, to indicate the marvellous *finale* to this most strange series of chemical reactions—the production of a brilliant red dye possessing such wonderful intensity and beauty! However charming is the result, we must not forget its humble origin—a lump of coal!

By treating aniline with certain other chemical substances, magenta, mauve, fuchsine, roseine, eosine, and many shades of blue, green, and other colours and tints are produced, all remarkable for their beauty and vividness of hue.

Aniline is also obtained from indigo, but its production from coal is, to our view, one of the greatest marvels of science.

PIGMENTS.

Many of the best and most durable colours are the direct products of Nature; but the science of chemistry has from time to time added greatly to her bountiful store of ready-made pigments by mingling the contents of her vast laboratory in various ways to produce other tints or shades of colour to suit the requirements of man.

Of the natural colours, or those which are obtained direct from the earth, and brought into use without chemical aid, may be mentioned vermilion, ultramarine, the ochres, Venetian and other bright reds, gamboge, sepia, and many other less important colours. But some of these, as vermilion, ultramarine, and bright red, are extensively produced artificially, that is, by chemi-

cal means, to supply the large and increasing demand
which exists in all parts of the world.

Vermilion, or Cinnabar, is a native ore of mercury,
or quicksilver, and it is from this ore (sulphuret of
mercury) that most of the quicksilver is obtained in China
and other countries. It is of a fine red colour, and may
be produced artificially as follows: Melt together 10
drachms of powdered sulphur and 4 ounces of quick-
silver in a crucible. The heat is to be continued until
the mass begins to swell up, when the crucible is to be
removed from the fire and covered closely to prevent the
mixture from taking fire. When cold, reduce the mass
to a powder, and place this in a clean covered crucible,
and expose to a moderate heat, when the sulphuret of
mercury, or vermilion, will sublime and condense on the
interior of the vessel.

Ultramarine.—This beautiful blue pigment is obtained
from the native stone called *lapis-lazuli,* or *azure-stone.*
The mineral is first made red-hot, and is then plunged
into cold water. The brightest fragments are then selected,
and these are reduced to an impalpable powder by grind-
ing in a mortar. The powder is then mixed with a large
quantity of water, and after a few moments' repose, to
allow the heavier particles to subside, the water, in which
the finer particles are held in suspension, is then poured
into a separate vessel, when after a time the colour will
have deposited, and may be collected and dried, when it
is ready for use.

Ultramarine is prepared artificially, by chemical means,
and the result is a beautiful product nearly if not abso-
lutely as fine as the native colour It may be prepared by
heating in a crucible for many hours a mixture composed

of China clay (kaolin), sulphur, sulphate of soda, and charcoal

Cobalt blue.—This fine pale blue pigment may be easily formed by adding to a solution of nitrate of cobalt—that is, metallic cobalt dissolved in nitric acid—a solution of ammonia alum The precipitate which forms must be well washed and dried, and then exposed to a cherry-red heat in a crucible. The mass is then to be reduced to a fine powder, washed, and the finer particles separated as described in the treatment of ultramarine.

Indigo blue is a vegetable production obtained from the *Indigofera tinctoria,* a plant growing in India and America. The plant is steeped in water until fermentation occurs, when the colouring matter becomes dissolved, and a yellow solution is the result. This solution is first separated from the vegetable matter, and it is then briskly agitated or beaten for about two hours, so as to bring the solution in contact with the air. By this means a considerable change takes place, and a blue colour (indigo) deposits at the bottom of the vessel. The deposit is afterwards cut into small cakes and dried at a moderate heat.

When mixed with starch, and formed into a paste and dried, it forms the "washing blue" of the laundry.

Red pigments are of various hues or tints, and differ greatly in their chemical composition.

Carmine.—This delicate and costly pigment is obtained by chemical means from an insect called cochineal, which feeds upon certain species of *Cactus,* and thus becomes impregnated with a colouring matter of great beauty. At certain seasons the female insects are swept off the plants, when they are placed in heated ovens and thus killed and dried for market. The colouring matter of cochineal is

much used in dyeing and in imparting colour to sweet-meats, etc.

Carmine is extracted from cochineal by various processes, amongst the simplest of which is the following: Take, say, 1 ounce of cochineal and reduce it to a powder, place this in three half-pints of water in a small enamelled saucepan, and boil for a quarter of an hour. Now add 1 drachm of cream of tartar and again boil for ten minutes. Then add about 1 drachm of powdered alum and boil for two or three minutes longer. Remove the saucepan from the fire, and after about five minutes strain the liquor through a piece of muslin into a clean porcelain basin, and set this aside until the carmine has become deposited. The upper liquor may then be poured off, and the carmine collected and placed on a filter to drain. It should now be carefully dried over a water-bath or upon a lump of chalk. It is very important that the pigment should not be overheated, or its colour will be greatly deteriorated.

Liquid carmine is obtained by dissolving the pigment in liquid ammonia, in which it is completely soluble when pure.

Red ochre is a native earthy substance containing peroxide of iron.

Light red is formed by submitting yellow ochre (an aluminous earth impregnated with oxide of iron) to a red heat, and then grinding and washing out the impalpable powder.

Orange red is prepared by calcining white-lead.

Red-lead, or **Minium,** is obtained by heating the yellow protoxide of lead (massicot) in a reverberatory furnace, with frequent stirring, until the required colour is produced. Under certain conditions of temperature the yellow protoxide of lead acquires a fine red colour.

Venetian red is a variety of ochre, or aluminous clay, imported from Italy.

Indian red is another ochreous pigment. It may be artificially prepared by calcining a mixture of peroxide of iron and red ochre

Yellow ochre is a native clay impregnated with oxide of iron.

Gamboge yellow is a gummy exudation of certain plants which grow in Siam, Ceylon, and elsewhere.

Lakes are prepared by precipitating the colouring matter from decoctions of cochineal, madder, Brazil-wood, etc., by means of a solution of tin, alum, or alumina. This latter substance has a strong affinity for animal and vegetable colouring matter, and when added to solutions containing them they readily combine and become deposited together.

Green pigments.—Although most of the useful tints of green are readily obtained by mixing yellows and blues in varied proportions, there are certain green colours which cannot be procured by this means, as, for instance, emerald green. This beautiful but poisonous pigment is formed by mixing acetate of copper and arsenious acid, and boiling them together, when a fine green colour is formed.

Sepia.—This useful dark-brown pigment is a substance secreted by the *cuttlefish*. It is collected and dried, when it forms *crude sepia*. For artistic purposes it undergoes a still further treatment, by which it becomes purified.

Chrome yellows.—Orange chrome is obtained by adding to a solution of nitrate or acetate of lead a hot solution of bichromate of potash The addition of a little alkali, as, for instance, soda, deepens the colour. A rich orange-coloured precipitate of great density falls down, and

this, after repeated washing, is to be filtered and dried at a moderate heat.

Lemon chrome is made by employing the *chromate* of potash, instead of the *bichromate*, as the precipitant. The presence of a little sulphuric acid renders the colour lighter in tone

Naples yellow may be prepared by taking a mixture of powdered metallic antimony three parts, red-lead two parts, and oxide of zinc one part. These are to be intimately mixed, and calcined at a red heat in a crucible. The calx is then to be triturated, and the mass fused in a covered crucible The fused mass is then to be well ground with a pestle and mortar, and then mixed with a large quantity of water, when the finer particles in suspension may be collected as previously described

Black pigments.—Ivory and bone, when subjected to red heat while excluded from the air, and afterwards allowed to cool, form " charcoals " of great density of colour. When ground to an impalpable powder they yield very good blacks. Lampblack is a very fine black and more easily obtained; when worked up with gum and water it forms an excellent substitute for Indian ink.

SOAP-MAKING.

It is well known that grease or fatty matter will not mix or combine with water. If, however, we boil tallow—that is, refined suet, or " fat," or other greasy matter—for some time in a solution of caustic soda or potash, a chemical change takes place, and the compound formed, which is called soap, is readily miscible in water.

Now, tallow is composed of two substances known

respectively as *stearine* and *oleine*, the former being a crystalline substance somewhat resembling spermaceti, and the latter a fluid, oily matter. When tallow is subjected to the action of boiling caustic alkali (soda or potash), the *stearine* becomes converted into *stearic acid*, and the *oleine* into *oleic acid*. These two "fatty acids," as they are called, take up a certain amount of the soda or potash, forming *stearate of soda* and *oleate of soda* or potash, both compounds being *soluble in water*. This operation is termed *saponification*, or the conversion of fat into soap.

Without going deeply into the manufacture of soap, an outline of the process will prove both interesting and instructive. Soap is usually made in large iron coppers or pans capable of holding from 5 to 30 tons of material. Yellow soaps are made by steam-heat, and mottled soaps by means of a fire situated at the bottom of the pan or copper.

In charging a soap-copper with material, a ley made of caustic soda of a certain strength is first pumped in, being conveyed by long iron "shoots" from the alkali-tank. While this ley is running into the copper, the "goods," that is to say, the tallow or other fatty matter, are shovelled in by the workmen, and steam is then turned on. After a while a certain proportion of rosin is added, and the boiling allowed to continue until the materials are incorporated and become freely acted upon by the caustic alkali. When the first ley becomes exhausted, it is pumped out by means of a large pump reaching to the bottom of the copper, and a fresh supply of stronger caustic ley is pumped in. This renewal of ley and removal of the exhausted or "spent ley" is kept up, and the boiling continued until the soapboiler's judgment informs him

that the process of saponification is complete.   The process of boiling a batch of soap generally occupies several days When the soap has a tendency to boil over, the soapboiler stands, with shovel in hand, in front of the copper, and with this he breaks the froth or "fob" by throwing shovelfuls of the soap through the air to the back of the pan, which not only cools the surface of the soap in some degree, but disperses the air-bubbles, thus preventing the soap from boiling over.   During the boiling process coarse salt is thrown in by shovelfuls, which not only tends to increase the temperature of the boiling mass, but it also has the effect of separating the ley from the soap itself.

When the process appears near completion, the soap-boiler watches his copper with anxious care, using his shovel freely, by dipping it into the boiling mass, to determine the proper moment to shut off the steam.   Small samples are taken occasionally and set aside to cool, when they are examined to ascertain their texture.   If sufficiently hard and firm, the steam is then shut off, and the soap allowed to repose until the following day, when it is ready for "cleansing"—that is, pumping out the spent ley, and transferring the soap to the frames or moulds in which it is to be cast into blocks.

When all the ley is drawn off, a dark semifluid substance called "niggers" makes its appearance in the "shoot" which conveys the spent ley, and the pumping is then discontinued.   It is usual nowadays to remove yellow soaps from the copper by means of a steam-pump, whereas formerly large ladles were used for this purpose.

A series of iron frames, each capable of holding about 11 cwt of soap, are ranged in rows at a convenient distance apart, and to these the soap is next transferred.

The soap is first pumped into a round iron pan fixed to an iron framework running upon four wheels. This pan is furnished with a gate or opening at its base, into which is fitted a movable slide or shutter. When full, the pan is wheeled to frame No. 1, the shutter is raised, and the soap runs freely into the frame. This operation is continued until all the frames are filled.

In from two to three days the soap will have become "set," though not quite cold, and it is then ready for "cutting." This operation is conducted as follows: The sides and ends of the frame are disconnected by removing the screws which bound them together. The soap then stands in the form of a huge block resting upon the iron base of the frame. This is now scraped all over lightly to remove traces of lime-white with which the interior of the frames are painted to prevent the soap from adhering to them. A gauge is next taken, and the soap marked or notched at its four vertical edges into equidistant divisions of about $2\frac{1}{2}$ inches each. Two men now take a long steel wire, looped at each end, through which short wooden pegs are placed as handles. One man stands at one end of the block and places the wire in the first or upper notches, and the other then draws the wire through the soap horizontally, which separates the first or top layer. This is removed and cast aside, to be remelted in future batches. The soap is then cut into slabs until the last layer is reached. The slabs are next taken one by one and placed on a cutting-machine to be cross-cut into bars. The floor of this machine is grooved at every $2\frac{1}{2}$ inches, to admit the wire to pass clear of the bottom slab. The soap is now marked by a gauge—which consists of a lath of wood with iron points or pegs pro-

jecting at equal distances of $2\frac{1}{2}$ inches—from the top to the bottom on each side. The wire is now placed across the first notches and steadily drawn downward, the operation being continued until all the slabs are cross-cut. The soap is now in *bars* of 15 inches, and these are removed, a few at a time, and packed crosswise and apart, like newly-made bricks, to enable the soap to become dry on the surface, which not only improves its appearance, but makes it more convenient to handle.

Primrose soap of the best quality is made of the best London tallow and the finest pale American rosin. When conscientiously made—that is, without adulteration—it is undoubtedly the most elegant of our yellow soaps, and is in all respects the best soap for toilet purposes. The darker yellow soaps owe their colour chiefly to the rosin employed in their manufacture, but this in no way impairs the usefulness of the article as a detergent or cleansing medium

Adulterated or "cheapened" soaps at the present day form the chief study of the soapmaker. How to make soap with the least possible amount of fatty material and the largest possible proportion of water, and yet produce a hard soap, is the life-study of some soapmakers, and we may say that they have nearly succeeded in making soap out of nothing but water—and *glass*, we should have added, but this requires explanation. Silicate of soda, or *soluble glass*, is largely used by the soapmaker in forming what are called "liquored soaps." It is a thick viscous substance readily soluble in hot water. When diluted down to about 100° by Twaddle's hydrometer, a very large proportion of the solution may be added to melted soap. The silicate solution is introduced into the

soap by a process termed "crutching," which thoroughly incorporates it with the soap. Hand-crutches are sometimes employed, but steam-power is generally applied to this purpose. Sulphate of soda (Glauber's salt), melted soda crystals, and many other substances, are introduced into the so-called cheap soaps.

Mottled soap is made from kitchen-stuff, which is previously melted and clarified by "stuff-melters" before being sold to the soapmaker. Unlike yellow soap, which forms a close, homogeneous mass when finished, mottled soap is boiled to a "curd," as it is termed, and has a separated or curdled appearance when made. The "strike" or mottled appearance is sometimes produced by adding strong ley of crude soda to the nearly finished soap, and the soapboiler prides himself much upon the perfection of the marbled grain of his manufacture

Blue mottled soap is made chiefly with cocoa-nut and palm oils, with the addition of silicate of soda. The mottled effect is produced by introducing a thinnish mixture of ultramarine blue and water into the copper while the soap is boiling gently. If the soap has been properly made the colouring matter arranges itself in pretty streaks or spots in parts of the soap during the process of cooling; but when the soap is wanting in body, or too heavily "liquored," the colour will spread through the entire mass. In this case the soap is unsaleable, and requires to be remelted.

Soft soap is made from fish oils with caustic potash instead of soda.

Toilet or scented soaps are generally made from remelted yellow soaps to which a little "marine"—that is, cocoa-nut oil soap—is sometimes added to increase its lathering properties. Various perfumes in the form of

essential oils are used, and frequently colouring matters are introduced It is also a common practice to add a little pearl-ash to the remelted soap, but since this is apt to affect the skin, causing a disagreeable " smarting " sensation after using it, the introduction of this powerful alkali should be abandoned.

Transparent soap is made by dissolving good dry curd or almond soap in spirit of wine in a closed vessel, very gentle heat being applied.   After a while the clear portion is to be poured into shallow moulds ; these are to be set aside for several weeks until the resulting cakes are firm, though transparent This soap is sometimes formed into balls.   Any desired colour may be imparted to the soap when dissolved in the spirit, aniline colours being very suitable for the purpose from their great solubility in spirit of wine.

Of the numerous medicated and other "fancy" soaps it is scarcely necessary to refer, since many of them are merely useless nostrums.

CANDLE-MAKING.

There are many processes for making candles of the various kinds required for public use : these are either *moulded* or *dipped*.

Mould candles are cast in pewter moulds, highly polished inside, arranged perpendicularly in a wooden frame, in an inverted position—that is, the tops of the moulds downward.   The upper part of the frame has a shallow trough to hold the melted material of which the candles are made.   The wicks are passed through a small hole at the apex of the mould and an iron or brass wire

supports the opposite ends of the wicks, which are furnished
with loops for that purpose. When the wicks have been
properly adjusted, melted stearine or other material is
poured into the trough until the moulds become perfectly
filled. The frames are generally placed in rows, and a
great number are filled in one operation. When quite
cold the superfluous material is removed from the trough,
the wires drawn out, and the candles withdrawn, one by
one, by means of a hooked bodkin which is inserted into
the loop at the bottom of each wick.

Stearine candles are made from the hard crystalline
substance contained in tallow and certain vegeta
matters, as palm oil and cocoa-nut oil. The s
first converted into the "fatty acid" called s
accomplish which there are many processe
select the following: The fatty mate
melted at a high temperature, and is
or six per cent. of strong sulphuric a
mass is afterwards distilled by
steam. The hard fatty acid, *stea*
then separated from the softer
pressure. When the latter aci
acid is removed from the press
a hard brittle substance.
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Or tallow is boiled in
steam. Slaked lime (hy
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is called a "lime soap
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The sulphur

sulphate of lime, leaving the fatty acids free. The mass is
now allowed to rest, when the sulphate of lime subsides
and the fatty matter rises to the surface. When cool, this
is cut into small strips, which are placed in canvas bags
and submitted to considerable pressure, which separates
the stearic from the oleic or softer acid. The stearic acid,
after repeated melting and pressing, loses a further portion
of oleic acid; it is then melted once more, and poured into
vessels to cool. When cold it is exceedingly hard, and
has a fine crystalline appearance; it is used for the best
quality of candles. The oleic acid is chiefly used for soap-
...king.

osite candles, as they are called, are composed
acids obtained from palm and cocoa-nut oils.
manufacture is largely carried on at Price's
The fatty acids are obtained with-
nt, the oils being merely submitted
eated steam, which converts their
y acids and *glycerine*. The latter
arated, has no affinity for its old
is afterwards rectified by re-
ids are converted into candles.
made from the remarkable
hich their name is derived.
al-tar, peat, wood-tar, and
a material for candles this
n the elegant spermaceti.
superior to any other

nor dipped, but are
being sus-
with melted

wax, a ladle is dipped into this material and the wax poured over each wick in succession. By repeatedly pouring the melted wax over each preceding layer the required thickness is obtained. The candles are then removed one by one, and rolled on a hard and highly-polished wooden slab. A flat, polished piece of hardwood being held in both hands, is placed on the candle, and with moderate pressure it is rolled to and fro until smooth and bright

Dip candles are made from tallow, which is first melted and then allowed to cool down to the required temperature, when it is transferred to a vessel called the "cistern." A long balance-shaped beam is suspended from the ceiling of the dipping-room, to one end of which a wooden frame is attached for holding the "broaches," with the wicks arranged at the proper distances. The opposite end of the beam is furnished with a weight to counterbalance the frame, and to enable the workman to manipulate the dipping process with ease and dexterity. The end of the beam which supports the frame is placed immediately over the dipping-cistern.

The process of dipping consists in pressing the frame gently and steadily downward, by which the wicks become immersed in the melted tallow and receive their first layer or coating. The workman then allows the frame to rise a little, and by a skilful movement he brings the ends of the wicks in contact with a sloping board which is attached to the front of the cistern. This movement relieves the ends of the wick of any superfluity of tallow which attaches to them. The broach is then carefully removed and placed on a rack, and another one is treated as before. When all the prepared wicks have received a first coating, the pro-

cess is repeated through the whole series until candles of the required thickness are formed.

When cold, the candles are removed from the wooden rods which support them, and are then weighed into pounds. If they are "sixes," for instance—that is, six to the pound—the proper number is placed in the scale, when, if above the proper weight, a lighter or thinner candle is placed in the scale and a stouter one removed. Those who are accustomed to "pounding" candles, as the weighing is called, can tell to a nicety what sized candle to substitute in order to secure the level weight with rapidity. A short length of fine twine is next passed through the loops of the wicks, which is then tied, and the candles are ready for sale. In former days candles used to be "stored" for several months before being sold to the public.

Night-lights are generally made from cocoa-nut stearine, and are furnished with a very fine wick which enables them to burn for many hours. These are a substitute for the famous old "rushlight" of other days —a luminary once held in high esteem.

MANUFACTURE OF FIREWORKS.

The art of *pyrotechny*, as it is called, consists in combining sulphur, charcoal, and nitre in certain proportions, to which is added other substances which produce varied colours or brilliant starlike effects when discharged in the air. Steel, iron, copper, and zinc filings, resin, lycopodium, camphor, sulphuret of antimony, lampblack, and other materials are employed in various proportions, and the compositions are placed in cases or tubes made of cartridge-paper, which are arranged after certain designs, many of

is carried on upon a scale of great magnitude in Glasgow, Newcastle, and St Helen's, near Liverpool.

Soda was formerly obtained by burning certain kinds of seaweed, and then dissolving or washing out the carbonate of soda contained in the ashes. From this source large quantities of crude soda, under the name of *barilla, kelp*, etc, formerly came into the market from Spain, the Highlands of Scotland, and elsewhere, and soapmakers, glassmakers, and others were dependent upon this source until the manufacture of soda from sea-salt was introduced

The manufacture of soda by chemical means consists in treating sea-salt with oil of vitriol diluted with about 25 per cent of water, and submitting the mixture to a moderate heat in a furnace. As soon as the sulphuric acid comes in contact with the salt, fumes of hydrochloric acid are given off, which are condensed in a chimney or flue filled with coke, through which a stream of water passes, which absorbs the gaseous fumes. The acid liquid thus obtained is the *muriatic* or *hydrochloric acid* of commerce. Formerly, manufacturers of soda did not care to condense the hydrochloric acid fumes, but allowed them to pass into the air. The disastrous effects of the fumes upon the surrounding vegetation was so great that an Act of Parliament was passed to compel manufacturers to condense the acid. One manufacturer boasted that he would willingly pay £20,000 a year to be allowed to continue the nuisance—that is, to let the gas escape into the air rather than condense the fumes.

When the acid fumes cease to be given off, the mass remaining in the furnace is *sulphate of soda ;* this is mixed with an equal weight of chalk, and about half its weight of finely-powdered coal. This mixture is then subjected to

the heat of a reverberatory furnace until the sulphate of soda is thoroughly decomposed. During the process of calcination the mass is frequently stirred with an iron rod. The fused mass which results is then removed from the furnace and placed in iron troughs to cool, when it assumes a dark grey colour; this crude product contains about 23 per cent. of pure soda. It is then treated with warm water to wash out the soluble matter, and the clear liquor is evaporated to dryness, after which it is mixed with charcoal or coke-dust, and again heated in a furnace until all the sulphur is driven off. The resulting product is called "soda-ash," and is largely used in the manufacture of soap. It contains about 50 per cent. of pure soda. Dissolved in water, and afterwards evaporated and crystallized, this forms the ordinary "washing soda" of commerce.

When crystals of soda are reduced to a powder, and exposed to the air for a short time in a warm place, the salt loses its transparency, becomes white and powdery, when it forms ordinary carbonate of soda.

Bicarbonate of soda is made by triturating soda crystals and dried carbonate of soda together; these are placed in a chamber and carbonic acid forced in, under pressure for many hours, when the salt is found to have absorbed additional carbonic acid, forming a *bi*carbonate. It is this salt of soda with which effervescing powders are generally made.

Caustic soda.—When a solution of soda is boiled for a few hours in contact with recently slaked lime, the liquid becomes powerfully caustic, so much so that the smallest quantity applied to the tip of the tongue renders the part painful for many hours. Caustic soda has the property of rendering organic matters, such as oils and fat, miscible

with water, it is this property which makes it so valuable to the soapmaker, who, under the name of "ley," employs it in large quantities in his operations

MANUFACTURE OF SULPHURIC ACID.

Sulphuric acid, or oil of vitriol, was formerly obtained by subjecting sulphate of iron (*green vitriol* or *green copperas*) to the process of distillation. The thick oily liquid which passed over into the receiver was called *oil of vitriol* or *vitriolic* acid, a highly corrosive substance of great importance in the arts. This acid is now made by bringing the fumes of heated sulphur into contact with the fumes of nitric acid, by which a portion of the oxygen contained in the latter combines with the *sulphurous acid* fumes, converting them into *sulphuric acid*. The apparatus employed in the manufacture may be thus described: A large chamber constructed of stout timber, and lined with sheet lead, is placed on brick or stone supports or pillars. A chimney for the escape of nitrogen gas is fixed at one end of the chamber on its upper surface. An oven, with fireplace beneath, is situated below the chamber in which are the materials for generating the gaseous products from which the acid is formed. A steam-pipe enters the chamber, and this is connected to a boiler placed at a distance from the chamber. This arrangement constitutes the principal machinery required for the production of sulphuric acid.

The oven consists of a cast-iron plate about five or six feet long and four feet wide, surrounded by brickwork A pipe fitted into the upper arch of the brickwork is inserted into the chamber. A small fireplace is constructed

beneath the oven, and the smoke arising from the fuel is conducted by a flue to a chimney erected near the site of the chamber.

The following details of the process of sulphuric acid making, as given by Dr. Ure, will explain both the principle and practice of the operation —

"The production of sulphuric acid from sulphur and nitre may be elegantly illustrated by means of a globe with a stoppered hole at its side, and four bent glass tubes inserted into a leaden cap in its upper orifice. The first tube is to be connected with a heated matrass, disengaging sulphurous acid from copper filings and sulphuric acid; the second with a retort, disengaging more slowly deutoxide of azote (nitric oxide) from copper filings and nitric acid; the third with a vessel for furnishing steam in a moderate current towards the end of the process, where no water has been previously admitted into the balloon; the fourth tube may be upright, and terminate in a small funnel. Through the opening in the side of the globe atmospherical air is to be admitted from time to time by removing the stopper, after which the residuary lighter azote (nitrogen) may be allowed to escape by the funnel orifice.

"The nitric oxide first absorbs oxygen from the air, becomes, in consequence, nitrous acid vapour, which, giving up one-third of its oxygen to the sulphurous acid, converts this, with the aid of water, into sulphuric acid, while itself returning to the state of nitric oxide, is again qualified to take oxygen from the air and to transfer it to the sulphurous acid gas; and thus in perpetual rotation. These oxygenating and disoxygenating processes continue until nearly the whole oxygen of the atmospheric air contained in the globe is consumed. Were there little

aqueous vapour present, those gases would soon cease to operate upon each other; for though the nitric oxide became nitrous acid, this would oxygenate little of the sulphurous acid, because the three substances would condense into white crystals upon the sides of the balloon, like hoar-frost upon a window-pane in winter These indicate a deficiency of aqueous vapour, an excess of nitrous acid. On the admission of steam the crystals disappear, the sulphuric acid is liquefied, the nitrous acid is converted into nitric acid and nitric oxide; the former of which combines with the water, while the latter is converted by the atmospheric oxgyen into nitrous acid vapour. A certain quantity of water is therefore requisite to prevent the formation of that crystalline compound, which condenses the nitrous acid, and renders it inoperative in transforming fresh portions of sulphurous acid into sulphuric. On these principles alone is it possible to oxygenate the sulphurous acid, by the nitrous acid resuming and surrendering a dose of oxygen in perpetual alternation.

.   .   .   .

"There are at least two plans at present in use for burning the sulphur continuously in the oven. In the one, the sulphur is laid on the hearth (or rather on the flat hearth in the separate oven), and is kindled by a slight fire placed under it; which fire, however, is allowed to go out after the first day, because the oven becomes by that time sufficiently heated by the sulphur flames to carry on the subsequent combustion. Upon the hearth an iron tripod is set, supporting, a few inches above it, a hemispherical cast-iron bowl (basin) charged with nitre and its decomposing proportion of strong sulphuric acid.

"In the other plan, twelve parts of bruised sulphur and one

of nitre are mixed in a leaden trough on the floor with one of strong sulphuric acid, and the mixture is shovelled through the sliding iron door upon the hot hearth. The successive charges of sulphur are proportioned, of course, to the size of the chamber. In one of the largest, which is 120 feet long, 20 broad, and 16 high, 12 cwt. are burned in the course of twenty-four hours, divided into six charges, every fourth hour, of 2 cwt. each. In chambers of one-sixth greater capacity, containing 1400 metres cube, 1 ton of sulphur is burned in twenty-four hours. This immense production was first introduced at Chaunay and Dieuze, under the management of M. Clement Desormes. The bottom of the chamber should be covered at first with a thin stratum of sulphuric acid, which decomposes nitrous acid into oxygen and nitrous gas; but not with mere water, which would absorb the nitrous acid vapours and withdraw them from their aerial sphere of action. The vapour of nitric acid, disengaged from the nitre on the hearth of the oven, when brought into intimate contact with the sulphurous acid, either gives up oxygen to it, becomes itself nitrous gas, and converts it into sulphuric acid; or combines with the sulphurous acid into the crystalline compound above described, which, the moment it meets with moisture, is decomposed into sulphuric acid and nitrous gas. The atmospherical oxygen of the chamber immediately reconverts this gas into nitrous or nitric acid fumes, which are again ready, with the co-operation of sulphurous acid gas and aqueous vapour, to produce fresh quantities of hydrous (that is, containing water) sulphuric acid (oil of vitriol) and nitrous gas. At low temperatures, this curious play of chemical affinities has a great tendency to form the crystalline compound, and to deposit it in a crust of considerable

thickness (from one-half to 1 inch) on the sides of the chamber, so as to render the process inoperative. A circumstance of this kind occurred in a very striking manner, during winter, in a manufactory of oil of vitriol in Russia; and it has sometimes occurred to a moderate extent in Scotland. It is called at Marseilles the *maladie des chambres.* It may be certainly prevented by maintaining the interior of the chamber, by a jet of steam, at a temperature of 100° Fahr. When these crystals fall into the dilute acid at the bottom, they are decomposed with a violent effervescence, and a hissing gurgling noise, somewhat like that of a tun of beer in brisk fermentation."

At the present day nitrate of soda is employed instead of nitrate of potash (nitre or saltpetre of commerce) in the manufacture of sulphuric acid. A layer of about 3 inches of water is placed on the floor of the chamber, and this absorbs the *dry* acid as fast as it is formed. Jets of steam are allowed to pass into the chamber from time to time, in order to prevent the crystallization of the acid on the inner walls of the vessel. The liquid acid is run off when it has attained a certain strength or specific gravity, and this is concentrated by evaporation in shallow vessels, or platinum retorts. When a certain proportion of water has become expelled by evaporation, the acid is put into large green glass bottles enclosed in basket-work. These vessels are termed "carboys."

The sulphuric acid or oil of vitriol of commerce is nearly twice the weight of water—that is, 1·845, the specific gravity of water being 1000 at a temperature of 60° Fahr.

Considered in its simple aspect, the formation of sulphuric acid may be thus summarized: When sulphur is ignited, fumes are given off which, uniting with the

oxygen of the air, converts them into sulphur*ous* acid.   If now the fumes of nitric acid are allowed to come in contact with the sulphur fumes, a portion of the oxygen belonging to the nitric acid unites with the vapour, converting the sulphur*ous* acid into sulphur*ic* acid, or oil of vitriol

Besides being largely employed in the arts and in chemical manufactures, sulphuric acid occurs in many natural products—in gypsum, or sulphate of lime, which when calcined at a red heat forms the well-known plaster of Paris ; in sulphate of magnesia (Epsom salts), etc.

Muriatic acid, or **Hydrochloric acid,** is the well-known "spirit of salt" of commerce   It is readily formed by acting upon common salt (chloride of sodium) with sulphuric acid, with the addition of moderate heat, in a stoneware retort.   The acid fumes which escape are allowed to pass into water, which rapidly absorbs them, and after a while the liquid assumes the form of a strong solution of hydrochloric acid, containing about one-third pure acid.   A hundred cubic inches of water will absorb at least 48,000 cubic inches of acid in a gaseous state.

When all the acid is expelled, sulphate of soda (Glauber's salt) remains in the retort, in the form of a crystalline mass.   This salt is used in the manufacture of soda (see p 27).   Muriatic acid is not always manufactured directly as an article of commerce, but is chiefly a product resulting from the manufacture of soda.   Indeed, as compared with the two other mineral acids, sulphuric and nitric acids, it is of trifling value.   It may to a great extent be considered as a waste or secondary product occurring in the manufacture of soda, as will be seen when referring to that important article.

When pure, hydrochloric acid is a colourless, invisible gas. Exposed to the air, it gives off white fumes, and in the presence of the vapour of ammonia, with which it readily combines, it forms dense white fumes of muriate of ammonia (*chloride of ammonium*, or *sal ammoniac*).

Hydrochloric acid is useful in the arts in forming certain salts, which are termed *chlorides*, as chloride of zinc, etc. Combined with nitric acid, it forms the well-known *aqua regia*, so much used as a solvent of gold and platinum.

REFINING GOLD AND SILVER, AND ALLOYS OF GOLD.

Treatment of the ore.—The native ore of gold usually contains silver, copper, lead, iron, and sometimes platinum and its alloys, together with earthy matters. The process for extracting the gold and silver is as follows: A quantity of ore (say 4 ounces) is placed in a crucible and subjected to a red heat in a blast-furnace, and while hot is thrown into cold water, by which it becomes *disintegrated*—that is, separated. It is next dried, pulverized, and washed to remove the lighter particles. To the residuum is added 4 ounces each of nitre, common salt, and potash. The whole is then placed in a "skittle-pot," as it is called, which being narrow at top prevents the fused mass boiling over. It is then exposed in the furnace to a heat sufficient to reduce the salts to a thin flux. The crucible is then removed from the furnace and allowed to cool; when quite cold it is broken, and a metallic button will be obtained, which is to be weighed to ascertain the loss by foreign substances. The button, which consists of gold, silver, and platinum (if any

of the latter be present in the ore), is placed in a small Hessian crucible and returned to the furnace; when in a state of fusion it is removed and poured into a vessel of cold water kept in a state of agitation, when it becomes *granulated*—that is, formed into small grains or particles. The grains are then collected and dried, and one of them tested with nitric acid.   If silver and platinum predominate, the acid acts at once on the surface, if otherwise, 12 grains of the compound are taken and silver added grain by grain, fusing each time with the blowpipe on charcoal until the nitric acid acts upon the surface after being scraped to remove the oxide.   The button is then weighed to determine the quantity of silver which has been added Silver is then added to the rest of the grains in the same proportion as in the 12-grain test, which reduces its quality to what is called "the parting alloy"—viz. 9-24ths of gold. The mass is then fused as before in a crucible and re-granulated.   After this process the grains are digested in nitric acid in a Florence flask gently heated on a sand-bath to dissolve the silver and platinum; the grains become divested of their silver, but still keep their form, although in a porous or spongy condition and of a brown colour.

The grains of gold are next repeatedly washed in boiling water to remove any trace of nitrate of silver which may remain. The gold is now *annealed*—that is, made red-hot —and finally mixed with a small quantity of potash, and fused into a button, which is then perfectly pure

The silver is obtained in a metallic state by placing strips of copper in the dilute solution, which reduces it to the form of a grey metallic semi-crystalline powder; this is afterwards well washed, dried, mixed with potash, and fused into a button of pure silver.

Alloys of gold.—The precious metal is fused, or alloyed, with silver and copper in various proportions for the manufacture of various articles of jewellery, etc. Some of the principal alloys are given below.

Twenty-two carat alloy consists of—

	oz.	dwt	grs.
Gold	0	18	8
Silver	0	0	16
Copper	0	1	0
	1	0	0

The silver and copper are first placed in a crucible with a little borax, and the crucible is then submitted to a strong heat in a forge-fire; and when these metals are melted, the gold is added, and the heat kept up until the mass assumes the appearance of an apparently transparent globule of a light green colour. The molten alloy is then poured into a mould called a *skillet*, and when cold, the ingot, as it is termed, is rolled to a certain thickness, when it is cut into stripes with a pair of shears, and may be drawn into wire or rolled into thin plates. Wedding rings are made of this alloy.

The solder employed for uniting joints or surfaces of the above alloy is composed of—

	dwt	grs.
Twenty-two carat gold	1	0
Silver	0	3
Copper	0	2
	1	5

The process of soldering—that is, uniting two parts of metal together—is conducted as follows: The parts to be

united are first scraped or filed; they are then brought together and secured by thin iron "binding wire." A lump of borax is then rubbed upon a piece of slate, with the addition of a little water, until a pasty mass is obtained. The part to be soldered is then brushed over with the borax paste, and small fragments of the gold solder are placed on the part to be joined. The article is laid on a flat piece of charcoal, and the flame of a blowpipe is then brought to bear upon the spot to be united until the solder *runs*, as it is called, when the operation is complete, and a perfect union of the parts is effected. The article is now dropped into dilute sulphuric acid, which dissolves the fused borax; it is then filed into shape, and rendered smooth by rubbing with Water-of-Ayr stone.

In order to give the alloy the appearance of fine gold the article has now to be "coloured"—that is, boiled in a mixture of nitre, common salt, and alum made into a paste with water, and heated in a crucible. This mixture removes the silver and copper from the *surface* of the alloy, whereby it assumes the beautiful colour of perfectly fine or pure gold.

Twenty carat alloy is composed of—

							oz	dwt	grs
Gold .	.	.	.	.	,	.	0	16	16
Silver	.	.	.	.	.	.	0	1	12
Copper	.	.	.	.	.	.	0	1	20
							1	0	0

Cast jewellery, such as rings in which fragile gems are set, is generally made of this alloy, owing to its being very soft and ductile, and thus easily pressed over the edges of such brittle stones as turquoises, opals, emeralds, etc.

The solder for this alloy is formed of—

						dwt	grs.
Gold (twenty carat)	.	.	.	.	.	1	0
Silver	.	.	.	.	.	0	3
Copper	.	.	.	.	.	0	2
						1	5

The next, and most important alloy of gold is that termed the eighteen carat alloy. It is used in the manufacture of watch-cases, mourning rings, etc., and is the lowest standard marked at the "Hall." It is composed of three-fourths gold and one-fourth alloy, thus:—

						oz	dwt	gis
Fine gold	.	.	.	.	.	0	15	0
Silver	.	.	.	.	.	0	3	0
Copper	.	.	.	.	.	0	2	0
						1	0	0

The solder used for the above alloy is composed of—

						dwt.	grs.
Eighteen carat gold	.	.	.	.	.	1	0
Silver	.	.	.	.	.	0	4
Brass	.	.	.	.	.	0	2
						1	6

An alloy of gold much used in the manufacture of chains, bracelets, and many other articles of jewellery, and which are generally retailed under the attractive title of "fine gold," is composed of—

						oz	dwt.	grs.
Gold	.	.	.	.	.	0	13	8
Silver	.	.	.	.	.	0	2	8
Copper	.	.	.	.	.	0	4	8
						1	0	0

This alloy was formerly used in the manufacture of what is called filagree jewellery, the light gossamer or wire work in fashion in the early part of this century, and the readiness with which it was "coloured"—that is, deprived of the silver and copper from its surface—was a great temptation to employ it extensively, since an article made with this alloy could readily be made to assume a virtue which it only possessed in a moderate degree

"Jewellers' gold," as it is termed, is a 12-carat alloy, consisting of—

						oz.	dwt	grs.
Fine gold	.	.	.	.	.	0	10	0
Silver	.	.	.	.	.	0	2	16
Copper	.	.	.	.	.	0	7	8
						1	0	0

It is a deep red colour, due to the large percentage of copper in its composition, is soft and ductile, and is easily worked. The solder employed with this alloy is termed "silver solder," and is composed of two parts silver to one part brass fused together. The silver solder is afterwards rolled out into small fragments, and applied with borax paste as before described.

Other alloys of gold are used in the manufacture of inferior articles of jewellery, but those given may be considered the most important It is not an uncommon practice to electro-gild articles made with a cheap alloy, inasmuch as they are incapable of being "coloured" by any other means.

ELECTRO-METALLUh

This name was given by the late Mr. A.
the art of depositing metals from their solution
of electricity The art was originally called
plastic," as applied to the process of electrotypi
the more comprehensive title adopted by Smee is
universally accepted as including the electro-deposition
metals generally.

The coating or covering metals with other metals by
electro-chemical agency is a vast and important industry,
and has made great progress since its birth, if we may say
so, in 1839. The principles of the art may be thus briefly
explained: When the two poles or terminal wires of a
voltaic battery in action are dipped into a metallic solution
—as, for example, a solution of sulphate of copper—a bright
deposit of this metal will soon be observed to have formed
on the wire proceeding from the zinc element of the
battery. This film is copper reduced to the metallic state
by the electro-decomposition of the solution; and if the
operation be continued for a time a thick deposit will
appear at the end of this wire, whereas the opposite wire
or "pole" (that which issues from the copper or carbon
element of the battery) will have become reduced in
thickness, if not entirely dissolved into the solution. In
other words, as fast as the copper is deposited upon the
negative pole (the wire issuing from the zinc) the *positive*
pole (proceeding from the copper element) becomes
dissolved, and thus re-supplies the solution with the metal
it has lost, or has yielded up to the negative end or pole of
the battery. This being the case, it is evident that if a

ı were attached to the positive pole
ɩpended to the negative pole, and both
ɔ solution when the battery was in full
ᴜhe process would result in an extensive
ɔf copper upon the article ın solution, while
ɹer plate would have proportionately lost in

is thus that the arts of electrotyping, gılding,
ɹvering, and nickel-plating are carried on. Solutions of
these metals are prepared from certain well-known formulæ,
and, aıded by strong currents of electrıcıty, vast quantities
of the respective metals are annually reduced from the
soluble to the metallıc state and deposited upon articles
of every conceıvable form

In *silvering*, or "electroplating," as it is termed, a solution
is made whıch consısts of from 1 to 4 ounces of sılver to
each gallon of solution   The sılver, whıch must be pure, is
first dissolved ın nıtric acid slıghtly dıluted with distılled
water.   A solutıon of cyanide of potassıum is then added,
whıch precıpıtates the silver in the form of a whıtısh
deposit of cyanide of sılver.   After repeated washing, the
precıpıtate is dıssolved in an *excess* of cyanıde of potassıum.
Water is then added to make up the proper quantity oɪ
solution, when it ıs put asıde to rest for a few hours, anɔ
the clear solution ıs then transferred to the plating-tank.

Articles to be sılvered are first well cleaned, by dıppınɡ
in a hot solution of potash, to remove grease ; they are theɪ
scoured with finely-powdered pumice and water, applıeɕ
with a hard brush.   After rınsing, they are suspended, ɓ
means of thin copper wires, from brass rods lying acroɕ
the tank, and whıch rods are connected by binding screɯ
to the negatıve pole of the battery.   Sheets or plates of fiɪ

silver are suspended from brass rods lying across the tank, alternately with those to which the articles are attached These rods are connected with the *positive* pole of the battery The silver plates are called *anodes*, or *dissolving plates*, and these require to be renewed from time to time as they become worn out or dissolved.

Electro-gilding.—A double cyanide of gold and potassium is generally used for this operation. The gold is first dissolved in *aqua regia* (a mixture of nitric and hydrochloric acids). The metal is then precipitated in the form of a cyanide of gold, by adding a solution of cyanide of potassium, and after well washing the precipitate with distilled water, it is re-dissolved in an excess of cyanide of potassium, water being added to make up the required quantity of solution. As the gold solution is generally worked hot, by which it becomes a better *conductor* of electricity, a much smaller quantity of metal is employed than is the case in silver solutions—about half an ounce to 1 ounce of gold to each gallon of solution being strong enough for most purposes. A few minutes' immersion in the gold bath will generally give a sufficiently good coating of the precious metal upon ordinary work. In some cases, as in gilding cheap jewellery, etc., a momentary immersion only is necessary. Gold plates or anodes are employed as the dissolving plates, and the work to be gilt is generally prepared by brushing with brass-wire brushes called "scratch brushes," moistened with stale beer, the operation being performed by means of a lathe.

Nickel-plating consists in employing a solution of nickel—usually the double sulphate of nickel and ammonium, stout cast plates of nickel for anodes, and a powerful battery current; or, more generally, the current obtained

from a dynamo-electric machine. This machine, which is worked by motive power, is capable of developing a large amount of electricity, and the quantity of work plated each day by one of these machines is really marvellous—four or five baths, holding from 250 to 300 gallons each, being kept in operation by the electricity generated in a dynamo-electric machine not much larger than an ordinary gas-meter

In the process of nickel-plating it is of the utmost importance that the work should be absolutely clean, or, as we call it, "chemically clean." The work is prepared by first boiling in a solution of caustic potash; it is then rinsed in water, afterwards dipped in a solution of cyanide of potassium and again rinsed; it is then scoured with pumice and water, and after a final dip in the cyanide, and rinsing, it is placed in the bath, and allowed to remain undisturbed until the required coating is obtained. Before nickel-plating, all work required to be bright is thoroughly polished, and it is afterwards *finished* by buffing at a lathe, Sheffield lime being employed for the purpose, which gives to the articles a surface of great brilliancy and beauty of polish

Electro-brassing consists in depositing an alloy of copper and zinc, solutions of these metals being prepared in the proportion to form the well-known alloy. Strong battery-power is employed, and when the operation is properly conducted, the deposit of brass is fully equal in colour to the best specimens of brass obtained by fusion of the respective metals, copper and zinc. Electro-brassing is greatly employed in coating fenders, stoves, and other articles intended to represent a brass or bronze surface. Steel pens are also electro-brassed before gilding, and in

some parts of Birmingham a large trade is carried on in this item alone.

Electrotyping is the art of depositing copper from its solution upon moulds or impressions of objects from which a copy in metal is desired. The moulds are generally made of wax or gutta-percha, though they may be made of fusible metal (an alloy of bismuth, lead, and tin). Wax and gutta-percha not being conductors of electricity, the surface of the mould made with these materials is brushed over with plumbago (black-lead), which gives a bright metallic lustre to the mould, which then receives the deposit freely. The art of electrotyping is very extensively practised, and by its means engravings and other works of art are copied, whereby the final impressions from such works are equal in beauty and detail to the first.

Colossal statues and groups of figures have been reproduced by the electrotype process, and these, when afterwards *bronzed,* as it is termed, present all the characteristic appearance of real bronze, while being considerably cheaper.

BLEACHING PALM OIL.

This important oil is obtained from the fruit of the *Elais Guineensis*, or Guinea palm. It is an orange-red substance of the consistence of butter, largely imported into this country for use in soap and candle making. About the year 1836, when the price of tallow was exceedingly high as compared with its present value, many attempts made by scientific men to decolour or bleach palm oil, so as to render it available, when mixed with tallow, in the manufacture of soap and candles. By one process the oil was subjected to a high temperature in an

iron pan, by which its natural red colour was destroyed, but the oil assumed a dingy brown tint Chlorine, a most powerful bleaching agent, was also employed; but it was found that after coming in contact with the soda ley in the process of soap-making, the colour somewhat returned. It was about this time that the author's father, the late Mr. Charles Watt, turned his attention to the subject, and after a long series of experiments conducted with great assiduity and care, his zeal was rewarded by the discovery of a process for bleaching palm oil which was thoroughly successful and effective.   After vainly trying every known decolouring agent, *chromic acid* occurred to the inventor, and this finally led to the development of a process, afterwards patented, which was adopted by nearly every soapmaker in the United Kingdom from that time up to the present.

This beautiful process may be thus described : The palm oil is first melted and then transferred to a wooden vat, and when at a temperature a little over blood-heat the following substances are introduced, and incorporated with the oil by brisk stirring: 28 lbs of bichromate of potash are dissolved in hot water; this solution is then poured into the oil, which is briskly stirred by "crutching," as it is termed.   About 60 lbs. of muriatic acid are then poured in and the stirring continued.   In a few moments evidence of chemical action shows itself, the oil increases in temperature, and assumes for a moment a dark colour. In from four to five minutes it becomes a rich emerald-green colour, at which point the decomposition of the colouring matter is complete.   A steam-pipe is then introduced, or pails of boiling water are poured in, after which the oil is allowed to repose.

In a few minutes after, the chemicals, combined with colouring matter, subside, and the oil, colourless as the purest tallow, rises to the surface. It is then ready for the soap or candle maker.

When the "chrome process," as it is familiarly called by the trade, was first discovered, bichromate of potash was worth about 1s. 8d. per lb. Its recovery after use, therefore, was a matter of considerable importance, from an economical point of view. This was subsequently effected as follows: Recently slaked lime was made into a thin paste of the consistence of cream, and this was added to the green liquor, resulting from the bleaching process, until all the chrome was deposited. This was afterwards well washed, dried, and subjected to a red heat on an iron slab until it assumed the bright yellow colour of chromate of lime. This chromate of lime was then again used in bleaching palm oil, about 60 lbs. being employed for each tun of oil, with the addition of muriatic acid; and thus the bleaching of oil and recovery of chrome are conducted with economy and incalculable advantage to the manufacturer.

Besides the rapidity and certainty of the process, bleaching by chromic acid was found to be perfect as far as regards eliminating the colouring matter of the oil; for when the process was properly conducted, the colour did not in the least degree return when the bleached oil came in contact with the caustic ley in the soap-copper. This important feature in the process at once secured for it the approval and adoption of the whole trade in the United Kingdom.

BEER—MALTING AND BREWING.

Although the production of this beverage may not, strictly speaking, be termed a scientific operation, it is nevertheless dependent upon chemical changes which require to be well understood to conduct its manufacture properly and successfully upon a large scale.

The chief operations are—*steeping* or soaking the barley, *malting*, *mashing*, formation of *wort*, *fermentation*, and *fining*

Steeping.—A large tank is filled to a certain height with water, and the barley is then thrown in and well stirred with long rakes. When the required quantity of barley has been emptied into the tank, a thin layer of water only will appear above the grain. The *steep* occupies about forty or fifty hours, according to the condition and age of the grain, the temperature of the air, etc., after which period it will have swollen considerably. This operation has the same effect as the moisture of the earth upon sown seed. The moisture expands the farina, and thus prepares the way for germination. After a while the *radicle*, or rootlet, appears at one end of the grain, followed in due time by the appearance of the *plumula*, or leaflet, at the same end, but which eventually turns round, beneath the husk, towards the other end of the seed. During this period of growth the starch contained in the seed undergoes a chemical change, by which it is converted into sugar and mucilage. If now the process of germination stopped by artificial means, the saccharine matter d ceases to undergo further change. This operation d *malting*, and is generally conducted as follows:

The water is first drawn off the steeped barley, which is afterwards washed with fresh water to remove any slimy matter that may have formed during the process. The grain is then placed, in square heaps about 12 inches high, upon a stone floor and left undisturbed for about twenty-four hours. By this time the barley becomes quite dry, and soon after it rises in temperature, yielding an agreeable perfume. This stage of the process is termed *sweating ;* and if the hand be thrust into one of the heaps it will not only feel exceedingly warm, but damp. The process of germination sets in at this period, and the radicles soon appear at every seed. The plumula generally makes its appearance about a day after the radicle. The malting is complete at this stage, or just before the plumula, or *acrospire,* as it is termed, becomes a perfect leaf.

The progress of growth is now checked by *kiln-drying.*

The malt-kiln is a large chamber fitted with perforated cast-iron plates, upon which the malt is laid to the depth of about 3 or 4 inches. A stove is placed beneath the chamber, and a fire kindled and kept up until the process is complete   The kiln is so constructed that the heat permeates the whole chamber so as to ensure uniformity in the process of drying. The temperature of the kiln is kept up to a little below 100° Fahr   The malt is repeatedly turned over until moisture ceases to be given off. When nearly dry, the temperature is gradually raised until the malt assumes a brownish-yellow colour. The fire is then allowed to die out and the malt left to cool. The malting process generally occupies about two days. When required for porter or stout brewing, the drying is conducted at a higher temperature, sometimes until the malt is partially charred.

This is objectionable, however, if carried too far, since a bitter principle is formed by the decomposition of the sugar, which is not agreeable to the taste. Malt should be of three colours—pale, yellow, and brown—the latter being employed for the darker coloured ales.

After drying, the roots and acrospire become brittle, and are easily separated from the malt. This is effected by sifting, a wire sieve being employed for the purpose. When required for brewing, the malt is first crushed in a mill, between rollers, whereby its constituents are more readily removed in the process of

Mashing.—It is usual to let the crushed malt lie exposed to the air for a few days, by which it attracts moisture from the air, and thus the farinaceous matter becomes soft and yields more readily to the action of water.

The object of mashing is not merely to dissolve out the sugar and mucilage, but to allow certain chemical changes to take place which greatly economize the process. The malted barley, besides yielding saccharine matter, contains starch, gluten, and a substance called diastase. These two latter substances have the property, when digested in hot water, of converting starch into sugar, so that by carefully conducting the mashing process a larger yield of saccharine or sweet matter is obtained.

In mashing, the crushed malt is first moistened with only sufficient water (at a temperature of about 157° Fahr.) to thoroughly penetrate the mass. The moistened malt is to be kept well agitated for about three-quarters of an hour, when a further quantity of water at 200° Fahr is to be run into the mash-tun, and the agitation continued until the mash assumes a uniform fluid state. The vessel is then to

be well covered in order to retain the heat In about an hour and a half the top of the tun is opened and the clear wort is drawn off. A second quantity of water at 200° Fahr. is now run into the mash-tun, and the whole well agitated as before. The wort at first drawn off is then pumped into the wort-copper and boiled. The wort of the second mash is then promptly drawn off, and added to the wort in the copper, and the boiling continued.

The addition of hops to the wort is the next consideration, and the quantity of hops will depend upon the quality or strength of the beer to be made, and the length of time it has to be kept. In making strong beer, $4\frac{1}{2}$ lbs. of hops are used for every quarter of malt, while for the stronger kinds of ale and porter 1 lb. of hops for every bushel of malt in the usual proportion Since hops have the power of checking the progress of fermentation beyond a certain stage, and more especially of preventing what is termed *acetous fermentation*— that is, the conversion of alcohol into acetic acid, or vinegar—they should be freely employed, up to a certain point, when beer has to be preserved for a lengthened period.

When the required quantity of hops has been added to the wort, the boiling of the latter is continued for several hours, according to the strength of the beer ; for the stronger beers the boiling should be kept up for a longer time than for the weaker kinds.

When the boiling is finished, the wort is run into a vessel called the " hop-back," to which a strainer is fixed to retain the hops. The strained wort is then pumped into the *coolers*. These coolers are large shallow vessels, the object of which is to cool the wort down to a tempera-

ture of from 54° to 64° Fahr   Fans are sometimes used to hasten the cooling.

Fermentation is conducted in large vats capable of holding from 1000 to 1500 barrels each, but the quantity of wort introduced into each vat is regulated so as to admit the head of yeast to rise without overflowing. A quantity of yeast is then mixed with a portion of the wort, and this is placed in a warm situation until fermentation sets in, when it is poured into the tun of wort and well stirred in.   The fermenting tun is then covered, and in about six or eight hours after the yeast is added fermentation proceeds briskly.   Carbonic acid gas escapes freely during the process, and renders a too close approach to the vat not only oppressive to the lungs but dangerous. While fermentation is going on, the temperature of the material rises considerably.   It is usual, when fermentation has progressed for a short time, to *cleanse* the beer, as it is termed—that is to say, it is removed to large vessels open at the top, each of which is furnished with a sloping tray for carrying off the excess of yeast which rises to the surface.

The beer is next removed to vessels called store-vats, which are generally placed in cool cellars, and for some time longer fermentation progresses, during which its spirituous strength is greatly augmented, and the beer becomes impregnated with carbonic acid gas, which imparts to it that agreeable freshness which is absent in stale or *flat* beer.   The beer is afterwards run into barrels, and is ready for use.   It is seldom, however, that the consumer has the honour of tasting beer in such a genuine condition, the retailer having tutored his customers to prefer the popular beverage after it has been subjected to a system

of "doctoring," often pernicious, and never advantageous, except from a "selling" point of view.

Beer is *fined* or clarified by means of isinglass. *Finings*, as they are called, are made from isinglass soaked in vinegar or sour beer. The isinglass swells up, becomes softened, and finally dissolves, when a further proportion of *hard* beer is added. One pound of isinglass will make twelve gallons of finings. About one pint of finings will generally clarify a barrel of beer. When using the finings, the required quantity is first mixed with a little beer, and this is whisked up to a frothy condition, after which it is poured into the barrel, briskly stirred in, and, the bung being replaced, the beer is allowed to rest for about twenty-four hours.

Pale ale is made from steam-dried malt and the young shoots of the hop. The darker or amber-coloured ales are made from a mixture of pale-yellow and brown malt. Sometimes raw grain is employed, with or without malt, in making beers, especially on the Continent.

Scotch ales, so famous for their excellent quality and agreeable flavour, are made from the best English barley and Kentish or Farnham hops. These are carefully selected, and employed in proportions which have proved to be specially suitable for producing ale of a superior quality.

PAPER-MAKING.

The art of paper-making appears to have been first invented in China about the commencement of the Christian era, or, according to some authorities, the art originated in Greece, where paper was first made from cotton fibres. But it was not until the fourteenth century that paper was

made from linen in Europe, namely, in Nuremburg, in
Germany. The first English paper-mill was erected in
Dartford, Kent, by a German in the service of Queen
Elizabeth, about the year 1588 It was not, however,
until about the middle of the last century that paper-mak-
ing was worked successfully in this country, most of our
supplies up to that time being derived from France and
Holland. It is now one of our most extensive industries,
and has been brought to great perfection, more especially
during the past thirty years, by improvements in machinery
and treatment of the materials employed in its manu-
facture.

Although the operations of paper-making are chiefly of a
mechanical nature, the science of chemistry has done much
towards perfecting the art, more especially in utilizing
other fibres than cotton in its manufacture. The greatly
increased demand for paper, caused by the removal of the
paper duty, naturally had the effect of enhancing the value
of cotton and linen rags, from which paper was made.
This demand led to a search for other fibrous material,
and paper made from straw came into the market in large
quantities. The brittle character of straw-paper, however,
and the disagreeable cracking noise which occurs when
handling it, renders it only suitable for a very cheap class
of printing paper; and although it is still much employed,
it can never be held in high estimation.

In the year 1853 the author's father patented a process
for converting wood fibre into paper, an outline of which
process will not be uninteresting to the reader. The wood
was first converted into shavings by steam planing
machinery; the shavings were then boiled for some time
in caustic soda, which dissolved out the resinous matter,

and after well washing they were placed in a chamber and subjected to the action of chlorine gas. After this operation, the shavings were again immersed in a solution of caustic soda, by which they became partially *pulped*. In this condition the pulp represented a brownish clotted mass called "half-stuff"—that is, only partially pulped. A solution of chloride of lime was next introduced, which bleached the mass to some extent, and this part of the process was continued until the pulp became absolutely white, when it was subjected to repeated washings until all traces of "bleach," or chloride of lime solution, were removed. The pulp was then in a condition to be converted into paper in the ordinary way.

The first public exhibition of the manufacture of paper from wood fibre took place at the Victoria Wharf, Regent's Park, in the year 1853, when Lord Derby (then Lord Stanley), the leading members of the press, and many gentlemen interested in the subject were present, and expressed their appreciation of the invention in unqualified terms of approbation. Although the process was not "taken up," as the phrase hath it, in this country, the American patent for the same invention was disposed of in the United States, and has been practically worked there for about twenty-five years upon a scale of great magnitude, and some of the finest specimens of printing produced in any country are obtained upon paper made from wood fibre in America.

At the exhibition referred to, specimens of newspaper and bank-note printing, water-colour painting, and many other interesting applications of the new paper were shown, and the brilliancy of the printed impressions was greatly admired.

Paper is now extensively made from esparto grass, and

many other fibrous substances, by which this important article has been rendered not only very plentiful but exceedingly cheap, and to this fact may be attributed the wondrous supply of cheap literature which now abounds in such profusion in this and other countries.

NITRO-GLYCERINE.

This interesting and powerful explosive substance was discovered by Sobrero; it is prepared much in the same way as gun-cotton, but requires even more care than that substance in its preparation. Nitro-glycerine is made as follows: 100 grammes of glycerine as concentrated as possible, at 302° Fahr. having a specific gravity of 1·262, are added by degrees to 200 cubic centimetres of mono-hydrated nitric acid, placed in a refrigerating mixture. At each addition of glycerine the temperature rises, and must be allowed to descend to 50° Fahr. It is necessary to be careful, during this solution of glycerine in nitric acid, that the temperature should be always *below* 30° Fahr.

The mixture is stirred with a glass rod, and where the glycerine and acid form a homogeneous liquid, 200 cubic centimetres of concentrated sulphuric · acid are added, in small portions at a time This part of the operation presents the most danger, if continual attention is not paid to the temperature. Experience teaches that there is no danger so long as the temperature does not exceed 30° Fahr. There was once a case in which the temperature rose as high as 50° Fahr., but between that and 68° Fahr. there was a sudden and violent reaction between the glycerine and nitric acid, in consequence of which the liquid was violently projected out of the vessel.

This inconvenience is completely avoided by keeping the temperature below 32° Fahr. With this precaution the nitro-glycerine, after adding the sulphuric acid, separates in the form of an oil floating on the acid, and is removed by means of a funnel with a tap. The quantity of this impure product, containing a little acid, amounts to about 200 grammes. About 20 grammes more are produced by mixing with water the acid which separates from it.

These 200 grammes are dissolved in as small a quantity of ether as possible, and this solution is agitated several times with cold water, until it no longer reddens litmus-paper. It is then evaporated on a sand bath, and heated until the nitro-glycerine no longer loses weight. The quantity of pure product thus formed amounts to 184 grammes.

Nitro-glycerine is a pale-yellow oily liquid. Heated to 320° Fahr it decomposes, at a higher temperature it explodes, breaking the vessel in which it is made, or else inflames without detonating. If a little nitro-glycerine is poured on a heated porcelain plate, violent detonation occurs, and the plate breaks. If struck with a hammer on an anvil, it detonates violently.

PUTTY-POWDER, OR OXIDE OF TIN.

This delicate substance is much employed in polishing metals, optical glasses, etc., and may be readily prepared by the following process, invented by M. of ⸺, jun., of Munich.

A solution of commercial chloride of tin is prepared by pouring on one part of the salt six parts of boiling distilled

...cer, and the solution is filtered through a cloth into a cylindrical glass vessel, in order to allow the foreign substances which are sometimes found in the chloride of commerce to deposit. The filtration by means of filtering-paper is too slow, and it is always attended with the loss of a subchloride which does not pass through filtering-paper; therefore this filtration is not practicable, and may be completely replaced by passing the solution through linen.

Into the still hot and almost clear solution of chloride of tin is poured a concentrated solution of oxalic acid; a white precipitate of oxalate of protoxide of tin is formed. After complete cooling, the liquor is decanted, and the precipitate is washed on a cloth with cold water until the washing water has no longer an acid reaction.

The oxalate of tin is afterwards heated, dried on an iron plate, or in a boiler of the same metal, over a small charcoal fire. The decomposition of the salt commences at red heat, and there remains, after the disengagement of carbonic acid gas, and carbonic oxide, a quantity of oxide of tin, which is found in the state of extreme division.

During the decomposition, which must be accelerated by stirring with an iron wire, the matter undergoes a considerable increase of bulk, consequently it is necessary to employ for this operation very spacious vessels, so as to avoid loss of product.

With regard to the quantity of the substances, it results from calculation that we obtain one part of oxide of tin by employing two parts of chloride of tin and one part of oxalic acid as ?

The trials which artisans have made of this oxide of tin for polishing metals, principally objects of steel and optical glasses, have proved that this product occurs in the finest

possible state of division, and that it presents great advantages in its application; there is no doubt that the oxide of tin obtained by the process indicated will be generally introduced into industry when the merits of the process have been fully tested.

SILVERING GLASS.

M. Pettijean's process consists essentially in the preparation of a solution containing oxide of silver, ammonia, nitric, and tartaric acids, able to deposit metallic silver either at common or somewhat elevated temperatures; and in the right application of this solution to glass, either in the form of plates or vessels.

One thousand five hundred and forty grains of nitrate of silver being treated with 955 grains of strong solution of ammonia, and afterwards with 7700 grains of water, yields a solution to which, when clear, 170 grains of tartaric acid dissolved in 680 grains of water is to be added, and then 152 cubic inches more of water, with good agitation. When the liquid has settled, the clear part is to be poured off; 152 cubic inches of water is to be added to the remaining solid matter, that as much may be dissolved as possible, and the clear fluids to be put together and increased by the further addition of 61 cubic inches of water. This is the silvering solution, No. 1; a second fluid, No. 2, is to be prepared in like manner, with this difference, that the tartaric acid is to be doubled in qua

The apparatus employed for the silvering of g consists of a cast-iron table-box, containing wa and a set of gas-burners beneath to he upper surface of the table is planed and s

zontal by a level, and covered by a varnished cloth.   Heat
is applied until the temperature is 140° Fahr.

The glass is well cleaned first with a cloth, after which
a plug of cotton, dipped in the silvering fluid, and a little
polishing powder, is carefully passed over the surface to
be silvered, and when this application is dry it is removed
by another plug of cotton, and the plate obtained perfectly
clean.   The glass is then laid on the table, a portion of
the silvering fluid poured on to the surface, and this
spread carefully over every part of it by a cylinder of
indiarubber stretched upon wood which has previously
been cleaned and wetted with the solution.   In this manner
a perfect wetting of the surface is obtained, and all air-
bubbles, etc., are removed.   Then more fluid is poured on
to the glass until it is covered with a layer about one-tenth
of an inch in depth, which easily stands upon it; and in
that state its temperature is allowed to rise.   In about ten
minutes or more silver begins to deposit on the glass, and
in fifteen or twenty minutes a uniform opaque coat, having
a greyish tint on the upper surface, is deposited.

After a certain time the glass employed is pushed to the
edge of the table and tilted, so that the fluid may pour off;
it is then washed with water.   The under surface presents
a perfectly brilliant metallic plate of high reflective power,
as high as any that silver can attain to; and the coat of
silver, though thin, is so strong as to sustain handling, and
so firm as to bear polishing on the back to any degree, by
rubbing with the hand and polishing powder.

The usual course in practice, however, is, when the
quantum of fluid is exhausted, to remove it, and apply
No. 2 solution; and when that has been removed,
is washed and dried, to cover the back surface

with a protective coat of black varnish. When the form of the glass varies, simple expedients are employed; and by their means either concave or convex, or corrugated surfaces are silvered, and bottles and vases are coated internally. It is easy to mend an injury in the silvering of a plate which has been coated by this process.

The proposed advantages are—the production of a perfect reflecting surface; the ability to repair; the mercantile economy of the process (the silver in a square yard of surface is worth 1s. 8d.); the certainty, simplicity, and quickness of the operation; and, above all, the dismissal of the use of mercury. In theory, the principles of the process justify the expectations, and in practice nothing as yet has occurred which is counter to them.

VINEGAR-MAKING.

This well-known and highly useful vegetable acid results from the *acetification* of substances containing alcohol. When ordinary beer, for example, is allowed to come in contact with the air, in warm weather, in a short time it acquires a sour taste, owing to the formation of acetic acid, or vinegar. When animal or vegetable matters are boiled in water, the infusion, after a time, becomes converted into a solution of acetic acid or vinegar. Starch, flour-paste, soups, etc., quickly "turn sour," as is well known, in hot weather. This acidity is due to the formation of acetic acid.

Most of the vinegar of the shops is made from malt and barley. The malt is first made into a mash with hot water. The wort is then run off, and fresh water at a higher temperature is then added to the drained malt. A

third water is afterwards employed, but this must be boiling hot, in order to extract all the soluble matters. When the liquor has cooled down to 75°, brewer's yeast is stirred in, and the wash is put into casks, which are laid on their sides, and kept in an apartment heated to at least 70° by hot-air pipes issuing from stoves placed outside the building.

Vinegar may be readily made from sugar. One pound and a half of sugar is dissolved in each gallon of water, which must be hot. When this has cooled down to 75°, yeast is added. Fermentation soon sets in, and after two or three days the clear liquor is racked off into a cask, when 1 lb. of bruised raisins and 1 ounce of crude tartar are added to each gallon of wash. Fermentation is allowed to proceed, as before, in open vessels, and when the acetification is complete the vinegar is fined by the addition of a little isinglass, after which it is bottled.

White-wine vinegar is made on the Continent from inferior wines and the juice of the grapes, together with wine-lees (or crude tartar). The process of manufacture is conducted upon the same principle as malt or British vinegar, and is considered preferable in flavour to the latter. At one time the Orleans vinegar was held in.high estimation, and justly so; but since then the improvements in the manufacture of British vinegar have been so considerable, and the supply so adequate to the demand, that the public have to a great extent accepted the home manufacture as equal to their requirements.

Aromatic vinegar is made by mixing certain essential oils, as cinnamon, cloves, rosemary, lavender, bergamot, neroli, etc., with glacial acetic acid, to which is added a little rectified spirit of wine. It forms an exceedingly

pungent and agreeable perfume for the relief of headache, and is useful in cases of fainting.

ACETIC ACID.

This powerful vegetable acid forms the basis of all species of vinegar. It is very commonly made, for commercial purposes, from the *acetate of soda*, this substance being a product in the manufacture of *pyroligneous acid*, or wood vinegar. The crystals of acetate of soda are placed in the body of a copper still, strong sulphuric acid is then added, with brisk stirring. The head of the still is then fixed in its proper place, and is well secured by luting. Gentle heat is then applied, and in a very short time the acetic acid distils over.

The acetic acid is next subjected to a process of purification. It is first mixed with a quantity of fused *chloride of calcium*, a substance having a great affinity for water, and is then redistilled, the acid passing through a refrigerator, when it assumes a beautifully crystallized form. These crystals are then well drained, at a temperature not higher than 45° Fahr., and are subsequently liquefied by placing them in a warmer atmosphere. The new liquid is agitated with peroxide of lead, and again and again distilled until the acid crystallizes at a temperature of 51° Fahr., when it represents the *glacial acid* so well known in photography.

Although there are many other processes for making acetic acid, the above is for all practical purposes a useful and economical one to follow.

Pyroligneous acid, or **Wood vinegar,** is a product resulting from the destructive distillation of wood. When

wood is subjected to heat, in an iron retort, its volatile matters, consisting of tar, creosote, pyroligneous acid, and various other liquid and gaseous matters, pass over into the receiver, and are afterwards treated and separated by redistillations. Wood naphtha, *pyroxylic spirit*, or *wood spirit* (hydrated oxide of methyl), which, when added to spirit of wine, forms the *methylated spirit* of the shops, is one of the most important products.

Pure pyroligneous acid is prepared by adding to the crude product recently slaked lime, which converts it into *acetate* or *pyrolignate of lime*. This is now subjected to gentle heat to destroy a portion of the empyreumatic matter with which it is combined; it is then again dissolved, and a solution of sulphate of soda added. A process of double decomposition, as it is termed, here takes place, *acetate of soda* being in solution, and sulphate of lime forming an insoluble precipitate at the bottom of the vessel The solution of acetate of soda is afterwards evaporated to dryness, then dissolved in water, and finally evaporated and crystallized.

The crystals of acetate of soda are then, as we have shown, treated with sulphuric acid in a still, and the acetic or pyroligneous acid allowed to distil slowly over, the product being the ordinary acetic acid of commerce.

The woods from which this acid is made are preferably those which have grown slowly upon a dry soil, or hard-woods, as they are called. Birch and red beech yield about $7\frac{1}{2}$ ounces of wood vinegar per pound of timber used. The timber from white beech, holly, horse-chestnut, and common ash yield a very strong wood vinegar.

BENZOLE, OR BENZINE COLLAS.

This important and interesting body was first discovered by Faraday, and has been before referred to as one of the products resulting from the destructive distillation of coal (see p. 2).   It may also be produced by decomposing benzoic acid by heat in presence of lime or baryta, and hence the name *benzole*   It exists in very considerable quantities in coal-tar naphtha, or that portion of the liquid products of the destructive distillation of coal which floats on water, boils below the temperature of 212° Fahr., and congeals to a solid mass at 32°.   The ordinary coal-tar naphtha of commerce is a very impure product   The mode of separating the benzole from it was first pointed out by Mansfield.   He took the ordinary naphtha, distilled it in a still with a double head, so constructed that only that portion of the naphtha which distils at the lowest temperature was collected; the product thus obtained was digested with oil of vitriol, which turned it black.   It is necessary that this part of the process be repeated at least twice, or the proper degree of purification will not be effected.   The benzole thus separated is washed with water, dried with anhydrous— that is, dry—sulphate of soda, and redistilled; it is then exposed to a freezing temperature, and when solid, subjected to pressure, when the pure benzole is obtained.

AMMONIA.

This is a gaseous compound of nitrogen and hydrogen. Combined with water, it forms the *liquid ammonia* of commerce, and in combination with hydrochloric acid it is

well known under the title of *sal-ammoniac*. This latter compound was originally imported into Europe from Egypt, where it was obtained by sublimation from the soot produced by burning camels' dung, near the temple of Jupiter Ammon, in a district called Ammonia, in the Lybian Desert

Ammonia is produced on the large scale chiefly from the gas-liquor of the gasworks. The liquor is first treated with sulphuric or hydrochloric acid; and it is then evaporated until crystallization of the salts (sulphate or muriate of ammonia) takes place.

Liquid ammonia is formed by mixing the sulphate or muriate of ammonia (sal-ammoniac) with recently slaked lime. This mixture is then put into an iron retort, subjected to heat, and the vapour of ammonia which is evolved is allowed to pass into water, which readily absorbs it, until the water becomes completely saturated. The rationale of the process may be thus briefly explained: A charge of muriate of ammonia and quicklime, worked up into a thinnish paste, is put into the retort; an iron pipe, fixed into the upper part of the retort, is connected by proper tubing to a Woulfe's bottle, the end of the tube reaching nearly to the bottom of the bottle, which is supplied with a layer of water, into which the end of the tube dips. A second Woulfe's bottle is connected by means of a bent tube with the former, through which the ammonia vapour passes into a layer of water as before, when the water in the first bottle is saturated. A third bottle, similarly arranged, receives the unabsorbed gas, and so on until the series is complete. These bottles must be kept cold by wet cloths while the distillation is progressing.

When all the ammonia has been expelled from the

retort, the fire is withdrawn, and the chloride of calcium, or sulphate of lime, which forms the residuum, is removed. The ammonia in the bottles is run into Winchester quart bottles or carboys, which are carefully stoppered, and should be kept in a cool situation.

Sal-ammoniac, or **chloride of ammonium,** is prepared, commercially, from *gas-liquor*. This is first saturated with hydrochloric acid, the offensive fumes which escape being conducted into the shaft of a chimney.

In very large operations the gas-liquor is placed in tanks capable of holding many thousand gallons of liquor; the acid is added gradually, with brisk agitation, so as to thoroughly incorporate it with the ammoniacal liquor. The quantity of acid to be added to each gallon of the liquor depends upon its ammoniacal strength; from $1\frac{1}{2}$ to 2 lbs. of acid per gallon being commonly employed to neutralize the ammonia When the saturation is complete, which is ascertained by means of test-paper (blue litmus-paper), the liquor, which is now *hydrochlorate of ammonia* or sal-ammoniac, in solution, is run into evaporating pans, which are sometimes very large pans or vats, made of cast iron, each capable of holding at least 1000 gallons. A furnace is constructed beneath these evaporators, in which the heat is kept up for a considerable time, or until the solution is in a condition to yield crystals. During the process of evaporation, the tar which rises to the surface is removed by skimming. When the evaporation has been carried far enough the concentrated liquor is put into vessels for crystallization, and this is occasionally stirred in order to check the formation of large crystals.

The product in this stage of the process is very impure, owing to the presence of matters derived from the tar, etc.

It has therefore to be subjected to purification. This is accomplished by *sublimation* When muriate of ammonia is moderately heated it volatilizes, and condenses in a solid form. This operation is generally conducted as follows: Cast-iron pans are set in brickwork with a furnace fire beneath each pan. A cast-iron or leaden dome or "head" is supplied to each pan The crude product obtained in the operation last described is placed in the pans and tightly pressed down, the heads are then placed over the pans, and are secured by clamps to the flanges of the pans. A small aperture at the top of each dome, fitted with a plug, admits of the escape of steam in the earlier part of the process, and also acts as a safety-valve in case the heating has been excessive. The regulation of the heat in the subliming operation is of the utmost importance, and requires much attention and skill on the part of the workmen, not only to secure a good commercial article, free from contamination by empyreumatic products of coal-tar, but also to prevent the head or dome from being blown off, a circumstance which would be fraught with much loss and mischief, even if personal injury did not occur.

The regulation of the heat in the sublimation of sal-ammoniac is sometimes determined by dropping water upon the head of the sublimer, when, if the temperature is proper, the drop of water simply boils and evaporates, but does not fly off as it would do if dropped upon a very hot surface. The time required to sublime the sal-ammoniac varies according to circumstances, such as the regulation of the heat and the size of the pans and sublimers employed; about five or six days may be considered the average period to complete the operation successfully. It is not usual to

sublime the whole of the salt contained in the crude product, otherwise certain volatile empyreumatic matters would pass over, which would contaminate the sal-ammoniac and render it unsaleable.

When the sublimation is complete, the fires are withdrawn, and the vessels allowed to cool. The heads are then removed, when the sublimed product will be found to assume the form of conical masses, about 4 or 5 inches in thickness. These cones are afterwards broken up into lumps, and are then placed in casks ready for sale.

When the ammoniacal liquor is neutralized with sulphuric acid instead of hydrochloric acid, a brown salt is obtained upon evaporation, which is the *sulphate* of ammonia. To convert this into *muriate* of ammonia (*sal-ammoniac*) an equal weight of common salt (chloride of sodium) is mixed with the salt before placing it in the subliming-pans. The sulphate of soda which is formed remains as a crystalline mass in the subliming-pans.

Cooley in his admirable Cyclopædia says: "Another method adopted, particularly on the Continent, and one equally applicable to any crude ammoniacal liquor rich in free ammonia or its carbonates, is to employ *sulphate of lime* as the source of sulphuric acid to neutralize the alkali [ammonia]. For this purpose the ammoniacal liquor is passed through a series of three or four covered wooden filters lined with lead, each containing a layer of crushed gypsum [native sulphate of lime] to the depth of 3 or 4 inches. These filters are usually set on a stage, one above another, and each communicates with a cistern placed beneath it by means of a leaden pipe furnished with a stopcock. This last is not opened until the liquor has remained some little time in the filter; and a pump throws

back once or oftener, upon each filter, what has already passed through it, before it is allowed to run into the next lower one. The liquor in each filter is not allowed to stand higher than from 2 to 3 inches above the surface of the gypsum, and the lowest, or last filter, is supplied with fresh gypsum at each separate charge of fresh liquor. A little water is lastly passed through the filters to wash out the portion of ammoniacal liquor absorbed or retained by the filtering media. In this way the gypsum of the filters is converted into chalk at the expense of the carbonate of ammonia in the solution; whilst the ammonia of the latter assumes the sulphuric acid of the gypsum, and is changed into carbonate of ammonia, which, with some free ammonia, is found in the filtrate. Sulphuric acid is next added to the filtered liquor to completely neutralize the free and carbonated alkali still existing in it; after which it is evaporated in a leaden boiler, with frequent skimming to remove floating oil, until of the specific gravity of 1·160. Chloride of sodium (sea-salt), in sufficient quantity to convert all the sulphate of ammonia in the liquid into hydrochlorate by double decomposition, is now added with constant stirring; after which the clear portion is either pumped or syphoned off into a somewhat deep reservoir or tank, where it is allowed to settle. The liquid, after sufficient repose, is pumped from the reservoir to the boilers and evaporated, with frequent agitation, so long as the sulphate of soda now existing in it falls to the bottom in granular crystals. These crystals are at intervals scraped to the cooler portion of the pan or boiler, whence they are removed by copper rakes and shovels into draining hoppers placed near the edges of the pan. The liquor in the boiler is now a strong solution of sal-

ammoniac, but still containing a little sulphate of soda, from which it has to be freed by crystallization With this object it is further concentrated, and then run or pumped into the crystallizers. In thirty or forty hours, or longer, the mother-liquor is run or pumped off. The mass of newly-formed crystals is then drained, and slightly washed, first with a little weak solution of sal-ammoniac, and next with a very little cold water, after which they are again well drained."

Pure commercial sal-ammoniac is generally met with in cakes about 4 or 5 inches in thickness; it is slightly flexible, and possesses a peculiar toughness when hammered, it is easily volatilized at a moderate heat, giving off dense white fumes, which condense on cooling, leaving no residue. This is therefore a simple test of its purity. The salt is much used in tinning iron and brass, and is also employed as a medicine.

POTASH.

When wood fuel is burned to ashes, and the ashes afterwards boiled in water, the latter becomes impregnated with an alkaline substance of great importance in the arts. The liquid is first filtered and then evaporated in iron pots until a dry mass is obtained, which is termed *potash*, a name derived from the fact of the ashes being boiled in pots, hence *potash* or *potashes*

America, which abounds in timber, is the chief source from which the potash of commerce is obtained. After the timber is felled it is piled up in large heaps and burned; the ashes are then collected and placed in large wooden tanks. A moderate quantity of water and quicklime are then added, and the mass is well stirred After a few hours'

repose the clear liquor is drawn off, and placed in iron pots, beneath which a fire is kindled. The whole of the water in time becomes expelled, and the heat is then increased until the dry mass becomes fused. When cold the mass is broken up, and put into air-tight casks, when it represents the American potash of commerce, a very powerful alkali rendered caustic by the addition of quicklime in the process of manufacture.

The substance called *pearl-ash* is prepared by calcining potashes until all the carbonaceous matter and sulphur are expelled; the mass is then treated with water, and the clear solution afterwards obtained is evaporated in shallow iron pans Towards the end of the operation the solidifying mass is kept constantly stirred, by which means it becomes broken up into granular lumps of a bluish-white colour.

When crude potash is treated with a moderate quantity of water, or about one and a half times its own weight, and a gentle heat applied, the most soluble product in the impure mass is its carbonate of potash, and this, consequently, becomes dissolved in the small bulk of water applied, while the less soluble neutral salts with which the crude article is contaminated remain at the bottom of the iron vessel, and the clear liquor which floats on the surface is a nearly pure solution of carbonate of potash.

If slaked lime be now added to the alkaline solution, and this boiled for an hour or so, caustic potash is formed, owing to the lime having taken up the carbonic acid with which the potash was combined.

The solution of caustic potash is next evaporated until it assumes a syrupy consistence, when it is poured on bright metallic plates and is afterwards broken into lumps; it

then represents the *caustic* or *potassa fusa* of the chemist, and is much employed in surgery. This substance must always be kept in well-stoppered bottles, since it is highly deliquescent—that is, having the power to absorb moisture from the atmosphere.

Carbonate of potassa, or salt of tartar, is prepared by dissolving pearl-ash in distilled water, and then filtering and evaporating the solution until the mass begins to thicken, when it requires to be briskly stirred, by which operation the salt assumes the form of white granular particles instead of becoming a concrete mass. In this state it forms the ordinary *salt of tartar* of commerce, and is much used in pharmacy, chemical manufactures, glass-making, dyeing, etc.

Carbonate of potash has so great an affinity for water that it dissolves in less than its own weight of that fluid. It is not soluble in alcohol; and if (being previously well dried) a little of this salt is added to a mixture of alcohol and water, as ordinary brandy, gin, rum, etc., after a while the potash will be found to assume a liquid form at the lower part of the bottle, while the spirit, nearly deprived of its water, floats on the surface. By this means an approximate estimate of the proportion of water in ordinary spirits, as sold by the retailer, may be readily ascertained. In some cases, however, the proportion of alcohol in common spirituous liquors is so small that a very large quantity of dried carbonate of potash is necessary to *separate* the water from the spirit.

When carrying out a series of experiments in this direction, with samples of spirits obtained from various taverns, the author has been much surprised to find in some cases little more than 10 per cent. of alcohol in the

bulk under examination. In order that the dishonest retailer may dilute his liquors *ad infinitum,* a tincture of capsicum, made from the *seeds* of the plant, is sometimes introduced, which enables the professed gin-drinker to enjoy the transient bliss of an irritated stomach at a cheap rate ! It is the author's opinion that the sophistication of English gin by the introduction of cayenne pepper, as a substitute for alcohol, is the chief cause of what is termed "mad drunkenness," and of the many brutal outrages which result from drinking this mischievous and pernicious adulterant.

Chlorate of potassa is a highly interesting compound of chlorine and potash. It may be readily prepared by passing a stream of chlorine gas through a warm solution of either carbonate of potash or caustic potash. This solution absorbs the gas up to a certain point, and when it ceases to do so the alkali has become neutralized, when the solution must be boiled for a short time, and afterwards gently evaporated. When a pellicle or film appears upon the surface, the vessel is placed aside to cool gradually In a little while crystallization takes place, and after a few hours a fine crop of crystals is obtained. The vessel is now to be tilted slightly, so that the crystals may be well drained; they are next placed on a filter, and washed quickly with *ice-cold* water. The *supernatant liquor,* or *mother-liquor*, which runs from the crystals must be again gently boiled and cooled as before, when a second crop of crystals, but not quite so pure, will be obtained.

Chlorate of potash is much used in pyrotechny, and in the manufacture of lucifer matches. When mixed with inflammable matter and heated, or even subjected to friction or high pressure, it explodes with great violence.

If chlorate of potash and sugar are mixed together, and a drop or two of strong sulphuric acid poured on the mass, an explosion takes place. The blow of a hammer will cause this mixture to detonate violently. This salt requires to be handled with great care, more especially if any inflammable matter is present

Nitrate of potassa, saltpetre, or **nitre,** occurs as a natural product of the soil in many parts of the earth, on the surface of sandstones, limestones, chalk, etc., and in caverns, and frequently upon the surface of the soil where animal matters have undergone gradual decomposition. It is prepared on the Continent artificially by the slow decomposition of animal matters and lime in the atmosphere, by which a nitrate of lime is formed, and this is afterwards mixed with water, which dissolves out the soluble nitrate of lime. Carbonate of potash is then added to this solution, which precipitates the lime in the form of carbonate, leaving nitrate of potash in solution This is afterwards evaporated and crystallized, and forms the *crude nitre* of commerce. This is purified by redissolving in boiling water and crystallizing in the usual way, the process being repeated to produce what is called *double-refined nitre.*

The chief uses of nitre are in the manufacture of gunpowder, fireworks, and nitric acid.

The substance commonly known as *salt of sorrel,* and which may be obtained by expressing the juice of the wood, or field sorrel, is a combination of oxalic acid and potash, or *oxalate* of potassa. It may be prepared artificially by saturating a solution of carbonate of potash with a solution of oxalic acid, and finally evaporating and crystallizing. The salt is frequently employed for removing the stains of

ink and "iron-mould" from linen, and also by bonnet-makers for bleaching straw.

Cream of tartar is composed of tartaric acid and potash, and occurs as a deposit on the interior of the vats during the fermentation of grape-juice in the process of wine-making The crude article is known as *argol* in commerce, and is either white or red, according to the colour of the grape from which the wine has been made. The cream of tartar of the shops, or *bitartrate of potash*, is prepared by first dissolving the crude article in boiling water. The solution is then evaporated to a certain point, and is then set aside to cool, when crystallization takes place. The crystals are then redissolved, and charcoal and an aluminous clay added, which removes any colouring matter present. After carefully decanting the liquor, it is set aside to cool gradually, when crystals deposit, which, after draining and drying, form ordinary cream of tartar.

Yellow prussiate of potash, or **ferrocyanide of potassium**. When pearl-ash is mixed with horns, hoofs, dried blood, and other animal matters, and iron filings, and the mixture is placed in a crucible or iron pot and subjected to a moderate heat, decomposition takes place, during which a substance called *ferrocyanide of potassium* is formed. The ingredients are frequently stirred during the process of ignition, and when the vapours which form cease to be evolved, the pasty mass is removed and cooled out of contact with the air. The mass is then treated with boiling water to dissolve out the soluble salt, and after filtration the clear liquor is evaporated to the point of crystallization, when it is set aside to cool. It is usual to suspend pieces of string in the concentrated liquor, to

which the crystals readily attach, and when the quantity of ferrocyanide solution is large, and the process of crystallization is conducted with care, a remarkably beautiful crop of crystals is obtained.   Indeed, in the whole range of chemical operations there is probably no finer display of beauty than in the crystallization of this remarkable substance.

Yellow prussiate of potash is largely employed in the manufacture of Prussian blue, and in making cyanide of potassium, a salt employed in considerable quantity by electroplaters and photographers

Cyanide of potassium.—When dried prussiate of potash is mixed with dried carbonate of potash, and the mixture heated in an iron vessel until fusion takes place, the resulting substance (cyanide of potassium) appears as a semifluid red-hot mass, which may be cast into cakes by pouring the fused material upon an iron plate.   When cold it is hard, brittle, and white.   This salt is much used by electroplaters in forming solutions of silver, gold, etc., and by photographers for "fixing" photographic images upon glass plates, by dissolving the iodide or bromide of silver which has not been acted upon by light, and the developing agents employed in the process.   It is highly poisonous, and attracts moisture from the air; it should therefore be kept in well-stoppered bottles, out of the reach of children and inexperienced persons.

NITRIC ACID, OR AQUAFORTIS.

This acid exists, in combination with potash, soda, lime, and magnesia, in certain minerals and plants.   Nitrate of potash, or saltpetre (a compound of nitric acid and potash),

is found largely in France, Germany, North America, Ceylon, China, and many other countries. When nitre is treated with sulphuric acid in a retort, and heat applied, nitric acid is evolved and *bisulphate of potash* remains behind. The acid is condensed in a receiver, and when the operation has been conducted with care it is very nearly pure.

For commercial purposes nitric acid is frequently made from nitrate of soda, a cheaper salt than nitre. The apparatus employed in making this acid is similar to that employed in manufacturing muriatic acid. A series of iron retorts are ranged in a row, built up with brickwork, and with a furnace fire beneath, the heat from which plays equally over the retorts. A series of three-necked carboys with bent tubes to connect them with each other, and also with the retorts, are placed in position to receive the acid as it distils over

The salt (nitrate of soda or nitrate of potash) is first placed in the retort, the lid of which is then carefully luted tight. The proper proportion of concentrated sulphuric acid is then poured into the retort through an aperture on its upper surface. The aperture is then connected, by a long glass tube, with a series of balloons, which, again, are connected with a certain number of empty receivers, which may be made either of glass or stoneware.

The furnace fires are then lighted, and the heat gradually raised until the acid passes over and condenses in the receivers   It is necessary that the sulphuric acid employed should be *very* concentrated, otherwise it will act upon the metal of the retorts.

Nitric acid may be purified by redistillation at a moderate heat.

When the operation is complete, the fires are withdrawn and the retorts allowed to cool.   The residuum, which is *sulphate of soda* (when the nitrate of soda has been employed in the process), is removed, and another charge of materials is introduced into the retorts.   The nitric acid is put into glass carboys, carefully stoppered and luted.

Nitric acid produces no effect upon gold or platinum, but when combined with hydrochloric acid it acts upon these metals, and with the addition of moderate heat dissolves them freely.   Two parts of hydrochloric acid and one part nitric acid forms the *aqua regia* of the alchemists. It was so named by them because it had the power to dissolve gold—the king of metals, as they called it.

GILDING WATCH MOVEMENTS.

This important industry, which is very extensively carried on in France and Switzerland, as also in this country, is very clearly described in Roseleur's treatise on electroplating, from which the following extract is taken:—

"This kind of gilding, which was for a long time a monopoly in Switzerland, is applied on a large scale in France only in the departments of Doubs and Jura, and especially at Besançon, and at Morez in Jura.   As several gilders of Paris begin to employ it quite successfully, I think that it is proper to devote a special chapter to the subject, and to thank at the same time M. Pinaire, gilder at Besançon, who, with a rare disinterestedness and liberality, not only imparted to me all of the processes, secrets, etc., employed in his own works, but also allowed me to publish them.

" In the gilding of watch parts, and other small articles

for watchmakers, gold is seldom applied directly upon the copper. In the majority of cases there is a preliminary operation, called graining, by which a very agreeable grained and slightly dead appearance is given to the articles. If we examine carefully the inside of a watch we will see the peculiar pointed dead lustre of the parts.

"This peculiar bright dead lustre, if I may so express myself, is totally different from what we have already mentioned. For instance, it does not resemble the dead lustre obtained by slow and quick electro-deposition of gold, silver, or copper, which is coarser and duller than that of watch parts. Neither does it resemble the dead lustre obtained with the compound acids, which is the result of a multitude of small holes formed by the juxta-position, upon a previously even surface, of a quantity of more or less large grains, *always in relief*.

"The graining may be produced by different methods, and upon gold, platinum, and silver; and since the latter metal is that preferred, we shall describe the process applied to it.

"This kind of gilding requires the following successive operations :—

"1. *Preparation of the watch parts.*—Coming from the hands of the watchmaker, they preserve the marks of the file, which are obliterated by rubbing upon a wet stone, and lastly upon an oilstone.

"2. The oil or grease which soils them is removed by boiling the watch parts for a few minutes in an alkaline solution made of one hundred parts of water and ten of caustic soda or potassa, and rinsing them in clean water, which should wet them thoroughly if all the oil has been removed. The articles are threaded upon a brass wire.

" 3. A few gilders then cleanse them rapidly by the compound acids for a bright lustre; others simply dry them carefully in sawdust from white wood.

" 4 *Holding the parts*—The parts thus prepared are fastened by means of brass pins with flat heads upon the even side of a block of cork.

" 5. The parts thus held upon the cork are thoroughly rubbed over with a brush entirely free from fatty matters, and charged with a paste of water and of the finest pumice-stone powder. The brush is made to move in circles in order not to abrade one side more than the other. The whole is thoroughly rinsed in clean water, and no particle of pumice-dust should remain upon the pieces of the cork.

" 6. Afterwards we plunge the cork and all into a mercurial solution, which very slightly whitens the copper, and is composed of—

Water	10 litres.
Nitrate of binoxide of mercury . . .	2 grammes.
Sulphuric acid	4 „

" The pieces are simply passed through the solution, and then rinsed. This operation, which too many gilders neglect, gives strength to the graining, which without it possesses no adherence, especially when the watch parts are made of white maillechort, dignified by the name of nickel, by watchmakers, or when the cuvettes contain tin in their composition

" 7. *Graining.*—In this state the parts are ready for the graining—that is to say, a silvering made in a particular manner.

" Nothing is more variable than the composition of the graining powders; and it may be said that each gilder has

his own formula, according to the desired fineness of the grain.

"Here are the formulæ which I have seen used in the works of M. Pinaire :—

Silver in impalpable powder . . .	30 grammes.
Bitartrate of potassa (cream of tartar) finely pulverized and passed through a silk sieve	300 ,,
Chloride of sodium (common salt) pulverized and sifted as above	1 kilogramme.

"At the present time, the majority of operators, instead of preparing their graining silver, prefer buying the Nuremberg powder, which is produced by grinding a mixture of honey and silver foil with a muller upon a ground-glass plate until the proper fineness is obtained. The silver is separated by dissolving the honey in boiling water, and washing the deposited metal in a filter until there is no remaining trace of honey. The silver is then carefully dried at a gentle heat.

"This silver, like bronze powders, is sold in small packages.

Silver powder	30 grammes.
Cream of tartar	120 to 150 ,,
Common salt (white and clean) . . .	100 ,,

or—

Silver powder	30 ,,
Cream of tartar	100 ,,
Common salt	1 kilogramme.

"All of these substances should be as pure as possible, and perfectly dry. Cream of tartar is generally dry; but common salt often needs, before or after it has been pulverized, a thorough desiccation in a porcelain or silver dish, in which it is kept stirred with a glass rod or a silver spoon.

"The mixture of the three substances must be thorough, and effected at a moderate and protracted heat.

"The graining is the coarser as there is more common salt in the mixture; and conversely, it is the finer and more condensed as the proportion of cream of tartar is greater, but it is then more difficult to scratch-brush.

"8. *The graining proper.*—This operation is effected as follows: A thin paste of one of the above mixtures with water is spread by means of a spatula upon the watch parts held upon the cork. The cork itself is fixed upon an earthenware dish, in which a movement of rotation is imparted by the left hand. An oval brush with close bristles is held in the right hand, and rubs the watch parts in every direction, but always with a rotary motion A new quantity of the paste is added two or three times, and rubbed in the manner indicated. The more we turn the brush and the cork, the rounder becomes the grain, which is a good quality; and the more paste we add, the larger the grain.

"The watchmakers generally require a fine grain, circular at its base, pointed at its apex, and close—that is to say, a multitude of juxtaposed small cones. A larger grain may, however, have a better appearance; but this depends on the nature and the size of the articles grained.

"9. When the desired grain is obtained, the watch parts are washed and then scratch-brushed. The wire brushes employed also come from Nuremberg, and are made of brass wires as fine as hair. As these wires are very stiff and springy, they will, when cut, bend and turn in every direction, and no work can be done with them. It is therefore absolutely necessary to anneal them more or less upon an even fire. An intelligent worker has always

three scratch-brushes annealed to different degrees: one which is *half soft*, or half annealed, for the first operation of uncovering the grain; one *harder*, or little annealed, for bringing up lustre; and one *very soft*, or fully annealed, used before gilding for removing the erasures which may have been made by the preceding tool, and for scratch-brushing after the gilding. Of course the scratch-brushing operation, like the graining proper, must be done by striking circles, and giving a rotary motion between the fingers to the tool. The cork is also now and then made to revolve. After a good scratch-brushing, the grain, seen through a magnifier, should be regular, homogeneous, and with an equal lustre all over. Decoctions of liquorice, saponaire, or Panama wood are employed in this operation."

MANUFACTURE OF GUNPOWDER.

This important explosive substance is essentially a mechanical mixture of saltpetre, or nitre, charcoal, and sulphur, and its explosiveness depends upon the purity of the materials used, the proportions in which they are combined, and the perfectness with which the mechanical mixture has been effected.

The nitre is first purified by *recrystallization*. Equal parts by weight of crude nitre and boiling water are placed in a suitable vessel, and well stirred until the salt is dissolved. The solution is then filtered, and set aside to cool gradually, when after a time about three-fourths of the nitre will have deposited in the form of crystals. The "mother-liquor" will retain any impurities with which the crude article may have been contaminated, while the crystals of nitre will be nearly pure. A further

crystallization, however, is necessary, and this is accomplished by redissolving the crystals in about two-thirds their weight of boiling water. On cooling, a crystalline mass is obtained which is sufficiently pure for practical purposes. In some gunpowder manufactories the nitre is subjected to repeated re-dissolution and crystallization, by which an almost chemically pure article is obtained.

Most of the nitre received in this country is imported from India, but a description of its manufacture in France will be interesting, since it illustrates the old saying, "Necessity is the mother of invention," and also shows how greatly Art is dependent upon science when the demands upon her resources exceed her power of supply.

"About the period of 1794 and 1795, under the pressure of the first wars of their Revolution, the French chemists employed by the Government contrived an expeditious, economical, and sufficiently effective mode of purifying their nitre. It must be observed that this salt, as brought to the gunpowder-works in France, is in general a much cruder article than that imported into this country from India. It is extracted from the nitrous salts contained in the mortar-rubbish of old buildings, especially those of the lowest and filthiest descriptions. By their former methods the French could not refine their nitre in less time than eight or ten days; and the salt was obtained in great lumps, very difficult to dry and divide; whereas the new process was so easy and so quick that in less than twenty-four hours, at one period of pressure, the crude saltpetre was converted into a pure salt, brought to perfect dryness, and in such a state of extreme division as to supersede the operations of grinding and sifting, whence also considerable waste was avoided.

"The following is a brief outline of this method, with certain improvements, as now practised in the establishment of the *Administration des poudres et salpêtres*, in France:—

"The refining boiler is charged overnight with 600 kilogrammes of water, and 1200 kilogrammes of saltpetre, as delivered by the *salpêtriers*. No more fire is applied than is adequate to effect the solution of this first charge of saltpetre. It may here be observed that such an article contains several deliquescent salts, and is much more soluble than pure nitre. On the morrow morning the fire is increased, and the boiler is charged at different intervals with fresh doses of saltpetre, till the whole amounts to 3000 kilogrammes. During these additions care is taken to stir the liquid very diligently, and to skim off the froth as it rises. When it has been for some time in ebullition, and when it may be presumed that the solution of the nitrous salts is effected, the muriate of soda is scooped out from the bottom of the boiler, and certain affusions or inspersions of cold water are made into the pot to quicken the precipitation of that portion which the boiling motion may have kept afloat. When no more is found to fall, 1 kilogramme of Flanders glue dissolved in a sufficient quantity of hot water is poured into the boiler; the mixture is thoroughly worked together, the froth being skimmed off with several successive inspersions of cold water till 400 additional kilogrammes have been introduced, constituting altogether 1000 kilogrammes.

"When the refining liquor affords no more froth, and is grown perfectly clear, all manipulation must cease. The fire is withdrawn, with the exception of a mere kindling, so as to maintain the tempe___   ___ll the next morning at about 88° Centigrade=190·4

" This liquor is now transferred by hand-basins into the crystallizing reservoirs, taking care to disturb the solution as little as possible, and to leave untouched the impure matter at the bottom.

" The contents of the long crystallizing cisterns are stirred backwards and forwards with wooden paddles in order to quicken the cooling, and the consequent precipitation of the nitre in minute crystals. These are raked as soon as they fall to the upper end of the doubly-inclined bottom of the crystallizer, and thence removed to the washing chests or boxes. By the incessant agitation of the liquor no large crystals of nitre can possibly form. When the temperature has fallen to within 7° or 8° Fahr. of the apartment —that is, after seven or eight hours—all the saltpetre that it can yield will have been obtained. By means of the double inward slope given to the crystallizer the supernatant liquid is collected in the middle of the breadth, and may be easily laded out.

" The saltpetre is shovelled out of the crystallizer into the washing-chests, and heaped up in them so as to stand about 6 or 7 inches above their upper edges, in order to allow for the subsidence which it must experience in the washing process. Each of these chests being thus filled, and their bottom holes being closed with plugs, the salt is besprinkled from the rose of a watering-can with successive quantities of water saturated with saltpetre, and also with pure water, till the liquor, when allowed to run off, indicates by the hydrometer a saturated solution. The water of each sprinkling ought to remain on the salt for two or three hours, and then it may be suffered to drain off through the plug-holes below for about an hour.

" All the liquor of drainage from the first watering, as

well as a portion of the second, is set aside, as being considerably loaded with the foreign salts of the nitre, in order to be evaporated in the sequel with the mother-waters The last portions are preserved because they contain almost nothing but nitre, and may therefore serve to wash another dose of that salt. It has been proved by experience that the quantity of water employed in washing need never exceed thirty-six sprinklings in the whole, composed of three waterings, of which the first two consist of fifteen, and the last of six pots=3 gallons E.; or, in other words, of fifteen sprinklings of water saturated with saltpetre, and twenty-one of pure water.

"The saltpetre, after remaining five or six days in the washing-chests, is transported into the drying reservoirs, heated by the flue of the nearest boiler; here it is stirred up from time to time with wooden shovels to prevent its adhering to the bottom or running into lumps, as well as to quicken the drying process. In the course of about four hours it gets completely dry, in which state it no longer sticks to the shovel, but falls down into a soft powder by pressure in the hand, and is perfectly white and pulverulent. It is now passed through a brass sieve to separate any small lumps or foreign particles accidentally present, and is then packed up in bags or barrels. Even in the shortest winter days the drying-basin may be twice charged, so as to dry 700 or 800 kilogrammes. By this operation the net produce of 3000 kilogrammes (3 tons) thus refined amounts to from 1750 to 1800 kilogrammes of very pure nitre, quite ready for the manufacture of gunpowder" (Ure).

The charcoal employed in gunpowder-making is manufactured from the lightest woods, or those which yield a very

porous charcoal, easily reduced to powder, and which leaves the least possible amount of ash when burned in the air. The black alder, poplar, chestnut, lime, willow, and the horse-chestnut have all been chosen for their respective merits, alder and poplar yielding a most excellent charcoal for this purpose.

In making the charcoal, the wood is selected when the tree is full of sap; the branches, which should not be more than three-quarters of an inch thick, are carefully stripped of their bark; these are then placed lengthwise in an iron retort, built in brickwork, so that the furnace fire may play equally over the surface of the retort. At one end of the retort is a door, and at the opposite end a pipe, terminating in a "worm," is attached, to allow the moisture, pyroligneous acid, and other products arising from the destructive distillation of wood to be collected. When all the volatile products have passed over, the fire is withdrawn and the retort allowed to cool. The charcoal is then carefully removed, and a fresh charge of timber introduced.

Manufacturers of gunpowder are more particular about the quality of their charcoal than the other ingredients, since this is more likely to vary in its quality.

The sulphur employed in gunpowder-making is purified either by fusion or distillation. When the former system is adopted, the sulphur is first melted and then allowed to remain, closely covered, for some hours, after which the lighter impurities are skimmed off the surface. The sulphur is then baled out and put into boxes to crystallize. Since sulphur melts at a very low temperature (230° Fahr.) it may be very readily purified by this means, but doubtless the process of distillation yields a finer

article for gunpowder-making. Sulphur is distilled in France upon a very extensive scale.

Mixing the ingredients.—These are first reduced separately to a fine powder by grinding, and are afterwards sifted through fine silk sieves. They are then carefully mixed together in the proper proportions, and are afterwards transferred to the "mill," in which, with the addition of a small quantity of water, they are mixed into a proper consistence, or "cake," as it is technically termed. When the mass has thus become thoroughly kneaded it is ready for the "corning-house," where the cake is converted into grains or "corns." It is now worked into a hard mass, which is afterwards broken up into small lumps. These are next placed in perforated copper sieves, on each of which a disc of hardwood is placed. The sieves are then placed on a frame and subjected to a rapid motion, which breaks the lumps into small grains, which fall through the holes in the sieves, the grains being afterwards separated from the finer particles by means of sieves of suitable degrees of fineness.

The powder is next rendered hard by being put into a cask, which is made to revolve. Sometimes bars of metal are placed longitudinally within the cask to assist the polishing of the grains.

The powder is afterwards dried by steam-heat or hot air.

The proportions of the ingredients used in making gunpowder vary considerably. In some English mills the proportions are—Nitre, 75; charcoal, 15; sulphur, 10, in 100 parts. In France—Nitre, 75; charcoal, 12 5; sulphur, 12·5. In Russia—Nitre, 73·78; charcoal, 13·59; sulphur, 12·63. French mining powder—Nitre, 65; charcoal, 15; sulphur, 20 parts in 100.

The sporting powder of our English mills is considered the best that is manufactured; indeed in all the varieties of gunpowder the British manufacturer has maintained a high reputation.

SMELTING OF METALS.

Iron.—This most important and useful metal exists in every part of the globe, in every soil, and in all mineral formations. It occurs, in combination with nickel, in meteoric ironstones, or meteorolites; combined with sulphur, in *iron pyrites*. It is also found associated with arsenic, in arsenical iron; with carbon, as *graphite*, or plumbago (carburet of iron); with phosphorus, as phosphate of iron; with sulphuric acid, as native sulphate of iron, or *green copperas*.

Iron also exists in Nature in combination with muriatic acid (muriate of iron), oxalic acid (oxalate of iron); as a black oxide, in magnetic iron-ore; as a red oxide, in hematite, and in combination with many other mineral substances. Ure thus eulogizes this noble metal: "It is capable of being cast in moulds of any form; of being drawn out into wires of any desired length or fineness; of being extended into plates or sheets; of being bent in every direction; of being sharpened, hardened, or softened at pleasure. Iron accommodates itself to all our wants, our desires, and even our caprices: it is equally serviceable to the arts, the sciences, to agriculture and war; the same ore furnishes the sword, the ploughshare, the scythe, the pruning-hook, the needle, the graver, the spring of a watch or of a carriage, the chisel, the chain, the anchor, the compass, the cannon, and the bomb. It is a medicine of much virtue, and the only metal friendly to the human frame."

To this we may add that it furnishes our vast railway system, our ironclads and mercantile fleet, our electric lighting apparatus, our sewing-machines, our telegraph wires, and our cutlery.

Iron has been found, though very rarely, in the pure state. Steel-iron has also been discovered in small quantities, generally in the form of small globules or buttons.

Magnetic iron-ore, or *loadstone,* is a black oxide of iron. It possesses the power of attracting iron and steel, and one variety of the ore has two poles, north and south, like the artificial magnet, each of which will repel the corresponding poles (north or south) of the magnetic needle. The loadstone or native magnet has the power of imparting permanent magnetism to steel.

Of the numerous ores of iron found in this country, the clay ironstone, or carbonate of iron, is chiefly used for smelting. It abounds in the coal formations, being placed both above and below the seams of coal.

The principal sources of iron in England are the coal-fields of Staffordshire, Gloucestershire, Somersetshire, and Monmouthshire, in Wales. At Merthyr-Tydvil the iron-stone is very plentiful, and vast quantities of cast iron are annually produced by the numerous blast-furnaces erected in that locality. At Dudley, in Staffordshire, the clay ironstone occurs in abundance along with coal, limestone (which is used as a flux), and a peculiar clay, which is employed in lining the interior of the furnaces. This clay, which is obtained from Stour-bridge, is much used, owing to its refractory and infusible nature, in the manufacture of crucibles for melting cast steel, glass, gold and silver, and other metals.

The ironstone of South Wales yields about 33 parts of cast iron per 100 parts of the ore   The cast iron produced in this quarter, however, is seldom sent into the market until it has been converted into *bar iron.*

Formerly, charcoal made from wood used to be employed in smelting iron-ores, but the subsequent employment of coal for this purpose has entirely superseded the use of this substance, whereby a considerable saving in the cost of manufacture has been effected, while the production of the metal has been vastly increased.

The *blast-furnaces*, as they are termed, are constructed of brickwork, of a pyramidical or conical form, and are bound by strong iron hoops arranged at different distances; and several of these furnaces, connected with each other, are placed in a row.   These furnaces are from 30 to 60 feet high, and are supplied with an inclined railway, which extends to a platform fixed in front of the upper orifice of the furnaces, and which is used for the conveyance of the materials.   Waggons filled with material are drawn by chains or ropes, worked by steam-power, up this railway to the floor of the platform.

The charge of materials is from 5 to 6 cwt of coke, or from 3 to 4 cwt. of coal, and 5 or 6 cwt of roasted ore, according to its richness in metal.   The limestone, employed as a flux, is introduced in the proportion of about one-third of the weight of the roasted ore.   About thirty charges of material are given in every twelve hours, and about two "casts" are effected in twenty-four hours.   The lower part of the furnace, called the *hearth*, is the point at which the molten metal collects.   During the process of smelting, blasts of air are brought to play upon the interior of the furnace by means of blowing-machines worked by a steam-engine.

It occupies about fifteen days to get the blast-furnaces in regular heat, before the charging of the materials can be attempted. The coke is introduced by basketfuls, about thirteen of which go to the ton, the ore and limestone flux being brought forward by means of sheet-iron barrows. About $14\frac{1}{2}$ tons of coke, 16 tons of roasted ore, and $6\frac{3}{4}$ tons of limestone are introduced into each blast-furnace in twenty-four hours. From this about 7 tons of *pig iron* are obtained in every twelve hours. The "pigs" are about 3 feet long and 4 inches in thickness, weighing about $2\frac{1}{2}$ cwt. each.

Cast iron is *refined*, or converted into *bar iron*, by three different stages of treatment. The cast iron is first melted in a furnace of peculiar construction, and about 9 feet square. When fused, it is cooled by a peculiar process, when it becomes what is termed white cast iron, or "fine metal," suitable for making malleable iron. In this process the hearth of the furnace is first filled with coke, then six pigs of cast iron are laid on horizontally; these are then covered with coke. The fire is then lighted, and after a short time the blast is applied. Eventually the melted iron flows into the "crucible" of the furnace. When all the cast-iron pigs have become fused, the molten metal and slag are run out through a tap-hole, at the base of the furnace, into a loam-coated pit beneath. Cold water is then poured over the metal to render it brittle. The metal is now comparatively white, and has a fibrous texture.

The refined metal is next broken up into fragments, and is then ready for the process of *puddling*, which consists in again removing the metal to a reverberatory furnace, and treating it in a peculiar way. The fragments of refined metal are shovelled into the furnace, and piled upon each other on the sides of the *hearth*. The door of the furnace

is then closed and fuel introduced. When the thinner edges of the metal begin to melt, the workman opens a small hole in the furnace door, and with a rake detaches the melting metal, and prevents it from running into a fused or strictly molten state. By this treatment the iron assumes a pasty consistence, when the heat of the furnace is reduced. The metal is then worked about with a paddle, when it swells up, giving off fumes which burn with a blue flame. This operation is continued until the metal presents the appearance of fine sandlike granules. The heat is then increased, and the particles of metal become agglomerated. The workman now takes his paddle, dips it into the pasty mass, when a small portion becomes attached to the tool. He continues to do this until a ball of metal has been formed at the end of the paddle; this he detaches with a rake, and places it in the hottest part of the furnace. This operation is continued until all the metal is converted into balls, when the heat of the furnace is raised to enable the particles of metal to become welded together. The balls are afterwards removed from the furnace, when they are either subjected to the action of a powerful hammer or rollers.

There are many processes for the smelting of iron, but the outline given will, it is hoped, convey to the reader some idea of the rationale of the operation.

Copper.—The ores of copper are numerous, very variable in their characteristics, and in the percentage of pure metal contained in them. Some of the ores are exceedingly beautiful, as *malachite*, or native carbonate of copper; *emerald malachite*, containing oxide of copper, carbonate of lime, silica, etc.; *copper pyrites*, or *peacock copper*—so named from the beautiful rainbow tints which are observ-

able in some specimens of the ore. Copper-ores abound in Siberia, Sweden, Hungary, Cornwall, and other parts of the globe.

Sometimes copper occurs in the form of sulphuret, black oxide, red oxide, sulphate (blue-vitriol), phosphate, arseniate, chloride, etc. In Cornwall the copper occurs in veins in granite and greenish clay-slate. It is often associated with tin, which occurs in the veins formed in the rocks.

Owing to the absence of coal in the county of Cornwall, the ore is transmitted to South Wales for smelting purposes, and there the operation is conducted on a scale of great magnitude.

The ore is first picked or sorted; the larger lumps are then broken with a hammer and the richer fragments separated from the poorer, the latter being crushed and washed to separate the metal. The richer lumps are broken into small fragments upon an iron slab by means of a small hammer called a *beater*: this reduces the ore to pieces about the size of a nut. These fragments are collected and sent to the smelters

The ore is first *calcined* in a reverberatory furnace, the object of which is to expel the sulphur without fusing the metal. In charging the calcining furnace, about 3 tons of the ore are generally introduced; fire is then applied, which is allowed to increase in vigour up to a certain point —that is, as high as possible without melting the metal itself. To prevent the fusion of the metal, the ore is frequently stirred; and when the calcination is complete, the ore is lowered into an arch beneath the furnace, where it is allowed to cool.

The *melting process* consists in placing the calcined ore on the hearth of a furnace, when the door is closed and

luted, and heat applied until the metal fuses The molten mass is frequently stirred in order to separate the metal from the scoriæ, this being afterwards removed by means of a rake A second charge of calcined ore is then introduced, and the operation conducted as before, by which a further supply of melted metal is added to the *matt*, as it is called. After several charges the molten metal generally reaches up to the doorway, when the tap-hole is opened and the metal flows out and drops into a well or pit filled with water, by which means it becomes *granulated*, or separated into small grains. In this state the "coarse metal" contains about 33 per cent. of copper combined with iron and sulphur.

The next operation is the calcination of the matt, or coarse metal, the object of which is to remove the iron by oxidation To accomplish this the matt is again placed in a furnace and subjected to considerable heat, but not sufficient to fuse it, and it is frequently stirred to prevent the grains from becoming attached to each other. In about twenty-four hours the operation is complete.

The metal is next submitted to a second fusion, a certain amount of the scoriæ of the latter operation being added to assist the fusion, and the metal is afterwards run into water and granulated as before, or is cast into ingots. The metal now contains about 60 per cent. of copper. The metal is then subjected to repeated calcination and roasting, the object of which latter process is to oxidize the iron and other foreign metals contained in the copper. In *roasting*, the pigs of metal are placed on the hearth of the furnace, and heat applied gradually, in order to favour the oxidation of the metallic impurities. After a while the heat is augmented until the metal is fused, when it is

run into moulds.   It is now ready for the *refining* process.

In refining the copper, the pigs or ingots are first placed in the furnace, a moderate heat is then given, which assists in the further oxidation of any foreign metals remaining in the copper, and the temperature is gradually raised till perfect fusion takes place.   During the fusion of the metal it is kept well covered with charcoal until it acquires the characteristic brightness and redness of metallic copper.   Samples are taken from the furnace repeatedly during the process, and these are assayed and examined to determine the period at which the operation is complete.

After being examined as to its ductility and malleability, the copper is cast into ingots, when it is ready for the market.   When the copper is to be used in the manufacture of brass, it is supplied in the granulated form.

Silver is found in the metallic state in many parts of the earth, but most abundantly in North and South America. It also occurs in the form of chloride, sulphuret, etc ; and in combination with gold, antimony, lead, and other metals. In England silver is generally found associated with lead —sometimes in such small quantities that it scarcely pays to extract it from the ore.

The metal (silver) is generally extracted from its ores by the process of *amalgamation with mercury*, or quicksilver. This fluid metal readily dissolves silver and gold, forming an *amalgam ;* and being easily volatilized at a moderate heat, it can be separated from the more precious metals by distillation.   This important fact has been taken advantage of in the separation of silver from its earthy impurities.

The treatment of the ore in Mexico is as follows : It is

first broken into small pieces with hammers; those portions which do not exhibit metallic particles are cast aside, whilst the remaining fragments are picked and classified according to their apparent richness in metal. These particles are then crushed, and afterwards reduced to powder sufficiently fine for the metal to be attacked by the mercury. Water being used in the process of grinding, the resulting mass has a muddy consistence. When the grinding operation is complete, the moist ore is put into casks, and a sufficient quantity of quicksilver added to amalgamate the particles of metal contained in the mass. The casks are made to revolve by means of a shaft which passes through their axes. The consistence of the paste is of great importance, since if it be too thick the globules of mercury will not be able to get at the particles of silver, and if it be too thin, the mercury is liable to keep on the bottom of the revolving cask instead of diffusing itself freely through the mass.

Pieces of iron and sea-salt are also introduced into the cask, the object of which is to convert certain metallic chlorides present in the ore into chloride of iron (a soluble salt). The mercury takes up or dissolves the silver, gold, copper, lead, and antimony, forming an *amalgam,* as it is called. Towards the end of the operation a certain quantity of water is added, the casks are then made to revolve slowly, whereby the amalgam falls to the bottom. In treating 5 tons of roasted and crushed ore, $14\frac{1}{2}$ lbs. of iron and 2 lbs. $12\frac{1}{2}$ ounces of mercury are used.

The amalgam is afterwards put into wet canvas bags, and allowed to stand for some time in order that the un-combined globules of quicksilver may percolate through the pores of the bags. The bags are then subjected to pressure. The mercury is removed or separated from the

amalgam by distillation. This fluid metal being volatile, passes over into a receiver, whilst the metals with which it had combined during the revolving process remain behind, and are subsequently treated in a furnace. The alloy, for such it is, is put into plumbago crucibles and subjected to a high heat, whereby any volatile matters which it may contain (as arsenic, for example) become dissipated, and the combined silver, gold, copper, etc., are collected in the form of a metallic button.

The alloy is afterwards purified by *cupellation*, as it is technically called This is in reality a process of *oxidation*, having for its object the conversion of the inferior metals, such as copper, lead, tin, etc., into *oxides*, whereby they are more readily separated from gold and silver, while these metals, not having so great an affinity for oxygen as the former, retain the metallic form. The cupellation-furnace of some smelting-works consists of a bed of slag, or other refractory material, above which the "hearth" is placed, and this is composed of fireclay, bone-ash, and other infusible substances. A brickwork structure, with appropriate flues, fireplace, etc., surrounds the hearth, and proper openings are left for the admission of hot and cold blasts of air, and for the removal of the oxidized materials during the progress of the operation.

When the charge is introduced, the alloy is placed on the "sole" of the hearth, and the furnace is then heated to a certain temperature. A quantity of pure lead is then introduced, which, coming in contact with air, readily oxidizes, and the oxide of lead, or *litharge*, is removed from the surface of the melted metal as fast as it is formed. This process is kept up by well-regulated heat until the whole of the lead and the oxidizable metals (copper, tin, lead, etc.)

contained in the alloy have become converted into the form of oxide, leaving the silver and gold in combination, as a molten mass. This is afterwards allowed to cool, when it is removed from the cupel, and is then ready for further purification by repeated meltings, as before. A considerable portion of the lead becomes vitrified, and is absorbed by the cupel, from which it is afterwards extracted.

The litharge, or oxide of lead, is reduced to the metallic state by heating in a furnace with charcoal.

The silver may be separated from any gold which may be combined with it by first granulating the alloy—that is, melting it and pouring it into water—and afterwards dissolving in nitric acid, or boiling in sulphuric acid. When the silver is all dissolved, the gold remains in the form of a brown powder at the bottom of the dissolving vessel. The silver may be precipitated from its solution by placing fragments of copper or zinc in the solution, which readily reduce it to the metallic state, though in the form of minute particles of a grey colour. If this mass be washed and dried, and afterwards heated in a crucible in combination with dried carbonate of potash, the silver soon melts into small globules, which finally deposit at the bottom of the crucible, where they collect in the form of a bright metallic button. The crucible, or "melting-pot," is afterwards allowed to cool, when the pot is broken and the silver button removed. The silver is again melted and the metal poured into a mould.

The treatment of gold-ore is described at page 35.

Lead.—There are many ores of lead—the sulphuret, or *galena*, a compound of sulphur and lead; *minium*, or native red-lead; *argentiferous galena*, in which the metal is combined with silver, arseniate of lead, etc. The greater

part of our lead supply comes from Flintshire, Derbyshire, Cornwall, and other parts of Great Britain.

The ore is first selected, or picked, to separate the richer metallic particles from the foreign matters which surround it. It is then subjected to the process of grinding and washing, by which the metal becomes cleansed of its earthy impurities. The ore is next *roasted* in a furnace at a moderate heat; this operation is repeated at a somewhat higher temperature, and subsequently by two other meltings, at each of which the heat of the furnace is raised. At one period of the process the mass assumes a pasty consistence, by which the non-metallic impurities, slag etc., become separated, and when the heat is increased the metal finally collects at the bottom of the furnace in a tolerably pure state.

The litharge, or oxide of lead, which is formed during the refining process is converted into metallic lead by treatment in a reverberatory furnace. A layer of coal is first placed on the hearth of the furnace, and this soon becomes ignited by the fire placed beneath. When this burns brightly a mixture of litharge and fine coal is laid over the red-hot cinders. The heat of the furnace is so regulated as to allow the oxygen of the litharge to be taken up by the carbon of the burning coal, whereby it becomes reduced to metallic lead. The metal is afterwards run out by the tap-hole of the furnace, and is cast in iron vessels. It then represents the pig lead of commerce, and is very nearly pure.

Lead-ores containing silver are treated by cupellation, by which the lead becomes oxidized, or converted into litharge, and by this means the silver becomes separated. The litharge is afterwards reduced as above.

PHOTOGRAPHY.

The action of light upon certain salts of silver had long been known as a scientific fact before it was turned to practical account by the more recent researches of modern experimentalists. Sir Humphry Davy and Wedgwood were the first to endeavour to apply the discolouring influence of light upon salts of silver to art purposes; but although they succeeded in obtaining impressions of objects upon white paper or white leather saturated with nitrate of silver, they were unable to *fix* the image by removing the salt of silver *unacted* upon by light.

Daguerre, who had long been experimenting in this direction, succeeded, in the year 1839, in producing and fixing an image upon a silvered plate, and this may be considered as the true basis of the photographic art. Daguerre's process was simply this: A plate of silvered copper, highly polished, was exposed to the action of the vapour of *iodine*, which formed a delicate layer of *iodide of silver* upon its surface. When this plate was exposed in a camera, and the image reflected upon it, an invisible effect was produced, which was afterwards made manifest by subjecting the plate to the action of the vapour of mercury. Beautiful as the results obtained by this charming process undoubtedly were, the experimentalists in " heliography," or " sun-drawing," as the art was called, were restless until greater achievements were yet accomplished.

The *multiplication* of the photographic impressions was the subject of much thought and experiment, and to Mr. Fox Talbot's exertions in this direction the world is largely indebted for several ingenious and important inventions By dipping paper first in a solution of iodide of potassium,

and afterwards in a solution of nitrate of silver (by which a layer of *iodide of silver* was produced upon the paper), a *sensitive* surface was obtained, which when exposed in the camera was capable of receiving a *latent* impression, to be afterwards brought out, or *developed*, by means of gallic acid and nitrate of silver. The impression thus obtained, having the lights and shades reversed, was termed the *negative*, and from this any number of copies could be obtained upon paper rendered sensitive to the action of light. Mr. Fox Talbot for this purpose prepared his paper for printing *positives*, as they were termed, by dipping it first in a solution of common salt, and afterwards in a solution of nitrate of silver, by which chloride of silver, or "horn silver," as the ancients termed it, was formed, a salt readily acted upon by light.

The great desire, at this period of the photographic art, however, was to obtain a more transparent medium than paper for producing the photographic negative, and for this purpose glass naturally suggested itself. To obtain an adhesive film upon glass which could be rendered sensitive to light, by chemical agents, was the aim of those whom we may now term the early photographers. Albumen, or white of egg, to which a little iodide of potassium was added, was suggested by M. Niépce de Saint-Victor, but even this important suggestion failed to meet the full requirements of the photographer. It was not until the lamented Frederic Scott Archer communicated his invaluable "collodion process," as it is called, to the *Chemist* (a journal with which the author had been connected from its birth) that the photographic art became fully developed. Within a few weeks of the time when Scott Archer's simple yet invaluable process became known,

photography engrossed the attention of thousands. Camera-makers, opticians, chemists, at home and abroad, availed themselves of the opportunity the newly-developed art presented for the supply of apparatus and material. Shrewd persons with a few pounds at command opened studios for portrait-taking. In every available nook or corner of our towns—in yard, in tent, on house-top, and in field the "professional" photographer was to be found reaping his harvest of sixpences.

And this *furore* was soon extended to every civilized part of the globe

Working more for the love of science than for greed, poor Archer gave to the world that which should have made his fortune. He died a poor man. *Telle est la vie !*

The art of photography, practically considered, may be rendered thus. A solution of pyroxylin (see page 182), in ether and alcohol, is impregnated with a small quantity of iodide or bromide of potassium. This is generally known as "iodized collodion." When some of this is poured upon a clean glass plate (photographic plates are sold for this purpose), and the superfluity returned to the bottle by tilting the plate, a film remains upon the glass which is as translucent as the glass itself. Now if this plate be dipped into a weak solution of nitrate of silver, the iodide of potassium in the film soon unites with the nitrate of silver, forming *iodide of silver*, a yellow substance readily acted upon by light. If a plate be thus prepared, or rendered *sensitive* to the action of light, in a *dark room*, and afterwards placed in the dark slide of a camera, it is in a condition to receive the photographic image. The rationale of the process for taking a portrait, for example, is exceedingly simple. The

sitter is first *posed*—that is, placed in any desired position at a suitable distance from the camera; the photographer then proceeds to *focus* the sitter. To do this he covers the camera with a dark cloth, which he also places over his head, to enable him to see with distinctness the reflected figure of the sitter on the ground-glass screen at the back of the camera. By moving the lens backward and forward by means of a pinion attached to the brass tubing which supports the lens, the photographer obtains the correct focus upon the ground glass. He next places the "cap" on the lens, and removes the ground-glass focusing screen, and places the dark slide in its place. The shutter of the slide is then raised, and the operator, after requesting the sitter to keep perfectly still, removes the cap of the camera, whereby the reflected form of the sitter is thrown upon the sensitive plate. After a few seconds' exposure, the cap is again placed on the lens, the shutter of the dark slide closed, and the process of *developing* commenced. This must be conducted in an apartment rendered *light-tight*, if we may so call it. That is, the "actinic" or active rays of light must be prevented from entering the operating-room by means of yellow calico, or yellow glass, placed over the window.

A remarkable feature in the process is that the impression of the image is perfectly invisible. There is no perceptible effect produced upon the film by its exposure in the camera. The image, as it is termed, has to be brought out, or *developed*, by chemical means. A developing solution may be made of sulphate of iron (a substance which has the power of reducing the silver contained in nitrate of silver to the *metallic* state), or pyrogallic acid, with the addition of a little glacial acetic acid and alcohol. When

a small quantity of the developing solution is poured upon the plate (after exposure in the camera) a remarkable effect becomes manifest in a few seconds. The *latent* or invisible picture appears upon the surface of the plate—where all was blank before—every line, every item of detail being depicted, or "developed," as it is technically called, upon the delicate film.

At this stage of the process the picture has to be *fixed*—that is to say, those parts of the sensitive film which have not been acted upon by the light passing through the lens (as the shadows, or non-reflecting surfaces, for example) have to be relieved of the iodide of silver which has not been affected by the light. For this purpose a *fixing solution* is made either with cyanide of potassium or hyposulphite of soda. Solutions of these substances are powerful solvents of the iodide of silver, but do not readily affect reduced—that is, metallic—silver. Therefore, after a photographic impression has been developed and well washed, it is necessary to pour over the plate the fixing solution, which at once removes every trace of the iodide unacted upon, thus leaving the picture clear and distinct. After well washing, drying, and varnishing, the operation is complete, and the portrait may be mounted in a case, or *passe-partout*, and framed

The brief outline given above represents the operation of taking an ordinary *positive* portrait—that is, a picture which the sitter may put in his pocket a few minutes after the likeness has been "taken" in the camera. As we all know, there are countless hundreds—may we not say thousands?—of itinerant photographers who visit the seaside during the summer season, the racecourse and other places of public resort, who will give you a "c'rect paw-

trit" upon varnished iron (*ferrotype*) for the small sum of fourpence in less than five minutes!

Glass *negatives*, or pictures from which any number of copies may be obtained by the process of photographic printing, are taken exactly in the same way as positives, but the materials employed are of a rather more concentrated nature, the object being to obtain a denser impression—that is, a thicker deposit of silver—than is required for a direct positive. To accomplish this it is necessary (besides employing stronger solutions, etc.) to expose the plate for a little longer time in the camera, and after developing and washing the plate, the picture is *intensified* by the application of additional reduced silver. For this purpose a weak solution of pyrogallic acid is employed, to which is added two or three drops of the silver-bath used for exciting the plate in the first operation. This mixture is poured over the plate, which is then subjected to a gentle *rocking* motion, so as to keep the action uniform. After a few moments, when the plate is held up to the light the details of the picture will appear much more dense or opaque than before intensifying or redeveloping. When the required density is obtained, the "negative" is washed as before, and is then carefully dried and coated with a hard white varnish—a solution of amber in chloroform being much used for this purpose.

The process of *printing* may be thus briefly described: Sheets of paper, specially made for photographic purposes, are first coated with albumen (white of egg) to which a little common salt (chloride of sodium) or sal-ammoniac (chloride of ammonium) is added. The albumen is prepared by beating the whites of any given number of eggs to a perfect froth. After a few hours' repose the albumen

subsides in the form of a fluid, to which an equal quantity of water may be added, and to each ounce of this solution of albumen must be added 10 grains of common salt (recrystallized and purified) or sal-ammoniac

The albumen solution is placed in a large flat porcelain dish, and the sheets of paper are laid one by one on the surface of the liquid.   It is usual to lay one corner of the paper on the solution, and then to gradually, but promptly, float the entire sheet.   Almost immediately after the sheet has been laid on the albumen it is removed, hung up by two of its corners to drain, when a second sheet is floated as before, and so on.   When the albumen ceases to flow from the paper it is placed in a warm room to dry

When required for *printing*, the albumenized paper is rendered sensitive to the action of light by floating it for two or three minutes on a solution of nitrate of silver, made by dissolving 60 grains of nitrate of silver crystals in each ounce of distilled water used to make up the "sensitizing bath."   The paper is then suspended from one corner by means of a black pin or wooden "clip."   A small piece of blotting-paper is generally placed on the lower corner of the paper to absorb the last drop of nitrate solution. When the paper is dry (which must be effected in a dark room) the prepared surface is readily acted upon by strong light, owing to the formation of *chloride of silver* by the double decomposition of the salt contained in the albumen and the nitrate of silver of the sensitizing bath.

The operation of printing—that is, obtaining copies, or "positives," from the glass negative—is as follows: The negative is placed, film upward, in a "pressure frame" made for this purpose; a piece of prepared paper of proper size is then laid on the varnished side of the plate, the shutter of

the frame is then placed over the paper and secured by proper fastenings. The printing frame is now inverted, its glass side exposed to the light, and in a few moments the edges of the sensitized paper become darkened, and this goes on increasing in intensity until the operator thinks proper to examine the picture to ascertain if the exposure has been sufficient. To do this he unfastens one-half of the shutter (which is hinged at its centre), raises a corner of the picture, and if it is sufficiently printed he withdraws it by opening the other half of the shutter, and places another piece of sensitized paper upon the negative as before. When the required number of proofs have been obtained, these are placed in lukewarm water to dissolve out the *free* nitrate of silver from the paper. When sufficiently washed, the operation of *toning* is commenced

Toning consists in placing the prints, after well washing, in a weak solution of chloride of gold, to which is sometimes added a little carbonate of lime to neutralize any free acid present   The proofs are immersed in the toning-bath for a few minutes, when they gradually change colour, from a brick-red to a warm chocolate or purple brown, and if allowed to remain for a longer period the tone will almost approach a black colour. It is usual to remove the proofs from the toning-bath when they have acquired an agreeable deep brown tone. At this stage the pictures are removed from the bath and placed in a solution of hyposulphite of soda, which dissolves out the unaltered *chloride of silver.* This *fixing* process prevents the light from producing any further effect upon the white or clear parts of the prepared paper. In order to prevent the pictures from *fading* it is necessary that every trace of hyposulphite of soda be removed or washed out by con-

stant changes of water. When the washing has been properly effected, the resulting proofs (or positive pictures) are to all intents and purposes *permanent* if carefully preserved from the action of a humid atmosphere.

After washing and drying, the photographic prints are trimmed—that is, their rough edges are cleanly and neatly removed by means of a sharp knife, they are then ready to be mounted upon cardboard, after which they are sometimes rolled between two bright steel rollers in a suitable machine.

Although there are many other operations and processes involved in the beautiful art of photography, it is hoped that the slight sketch we have given will be deemed sufficient by those who do not desire to pursue it as a study. Those of our readers who would wish to make an acquaintance with the art will find some admirable handbooks on the subject. We may also state that the apparatus, materials, solutions, and all necessary information may readily be obtained from scientific instrument-makers and photographic chemists.

MANUFACTURE OF STARCH.

Starch consists of minute granules or particles of farina, which when examined under the microscope are found to be either round or oval, according to the source from which they have been obtained. These particles are insoluble in cold water, but readily soften in hot water, forming a thick pasty mass

Wheat-starch is made by first sifting the grain to cleanse it. It is then put into large vessels and covered

with water.   After remaining for some time under the influence of moisture, the grain swells and becomes softened, when it is easily crushed between the fingers.   The grain is then removed and placed in clean warm water. It is afterwards put into bags and pressed in a vessel containing water, by which means the water assumes a milky appearance.   The liquor containing the starch granules is transferred to a large vat or cistern, when after some hours' rest the starch deposits at the bottom of the vessel.   The clear liquor is then run off and a fresh quantity of liquor containing starch granules is run into the cistern, and thus a second layer of starch is obtained.   This operation is continued until a considerable depth of starch is deposited. It is then repeatedly washed until the last washing water is quite clear and colourless.   The starch is then purified —that is, separated from the gluten, sugar, vegetable albumen, etc, by a process of *acetous* fermentation which sets in, and this assists in bleaching the starch.   A slimy matter consisting of albumen and gluten rises to the surface of the mass after fermentation, and this is carefully removed and used as food for pigs, etc.

The mass at the bottom of the cistern now consists of layers of starch of various qualities   Each layer is then removed and put into a separate vessel.   The starch is then again mixed with water, and passed through fine sieves; it is then again allowed to deposit, the clear water run off, and the pasty mass is put into linen strainers and allowed to become nearly dry.   The starch is then cut into pieces and dried in a drying-room properly heated by stoves.   Sometimes the half-dry starch when cut into pieces is dried upon half-burned bricks, which being porous, absorb much of the moisture with which it is combined.

Starch is sometimes bleached by means of a solution of chloride of lime

When dry, starch splits up into prismatic columns of a very uniform character.

Potato-starch is made by first well washing the potatoes, and afterwards reducing them to a pulpy consistence in a rasping-machine. The pulp is next put into water, kept constantly agitated, and finally the liquor containing the starch is run off, passed through a fine sieve, and the granules allowed to deposit as before, when it is treated in much the same way as wheat-starch.

The delicate substance called *arrowroot* is pure starch obtained from the root of a plant named *Maranta arundinacea*, which grows in Jamaica and various islands in the West Indies. It is a remarkable fact that while the root of this plant furnishes us with a wholesome and agreeable food, the juice of the plant is highly poisonous. The same observation applies equally to the potato, the fruit or seed-vessels of which are exceedingly poisonous.

ELECTRIC LIGHTING; ITS APPLIANCES AND THEIR USES.

Although it would be impossible in a work of this varied character to give more than a faint outline of the principles of electric lighting and the apparatus employed in its development, the subject is far too interesting at the present time, when this system of illumination is rapidly gaining ground, to be passed over in silence.

Magneto-electricity was discovered by the great physicist the late Professor Faraday; and since this grand discovery was made known, scientific observers of all nations

have devoted much attention to the production of electricity by other means than the ordinary voltaic battery. Amongst the most assiduous and successful experimentalists in this direction is Dr. Werner Siemens, who in 1854 introduced his now famous armature, which, from its compact form, "permitted a very high velocity of rotation in an intense magnetic field, giving powerful alternating currents, which, when required, were *commutated* into one direction."

The next important discovery, due both to the late Sir C. Wheatstone and Dr. Siemens, was that of the *dynamo-electric machine.* The principle of this machine is thus described by Dr. Siemens himself: "Induced currents [of electricity] are directed through the coils of the electro-magnets which produce them, increasing their magnetic intensity, which in its turn strengthens the induced currents, and so on, accumulating by mutual action until a limit is reached. . . . When a closed electrical circuit is moved in the neighbourhood of a magnetic pole, so as to cut the lines of the magnetic force, a current is generated in the circuit, the direction of which depends upon whether the magnetic pole is N. or S. [north or south]; it also depends on the direction of motion of the circuit, and, according to the law of Lenz, the current generated is always such as to oppose the motion of the closed circuit. . . .

"The name *dynamo*-electric machine is given to it because the electric current is not induced by a *permanent magnet,* but is accumulated by the mutual action of electro-magnets and a revolving wire cylinder or armature. It is found that as the dynamic force required to drive the machine increases, so also does the electric current; it is therefore called a dynamo-electric machine."

The electric current is produced in a Siemens' machine by the rotation of coils of insulated copper wire—that is, wire covered by a non-conducting substance, such as cotton. These coils of insulated wire form the *armature* of the machine, and they are caused to rotate with great velocity by means of steam-power. Four electro-magnets, united in pairs, with curved bars connected to the soft iron cores of the magnets, are secured firmly to the sides or bottom of the cast-iron frame of the machine. Between these large electro-magnets the armature revolves, when currents of electricity are induced by the remanent magnetism in the soft iron bars of the magnets. These currents, at first very feeble, are directed through the collecting *brushes*, as they are called, into the electro-magnetic coils, thus strengthening the magnetism of the iron bars; these in their turn induce a still more powerful current of electricity in the revolving armature, or coil of insulated copper wire.

Dr. Siemens says " the electric current thus becomes stronger and stronger, and the armature therefore revolves in a magnetic field of the highest intensity, the limit of which is governed by the limit of saturation of the soft iron." By this it is understood that soft iron can only be made to *absorb*, as it were, a certain amount of electromagnetism.

When we reflect that formerly many attempts were made to produce the electric light by means of the galvanic battery, which involved the consumption of a large amount of metal and acid, and required a great deal of attention, the production of powerful electric currents by *motive power only* may fairly be considered one of the grandest discoveries which have yet emanated from the brain of man.

Various as are the contrivances by means of which powerful currents of electricity are obtained from dynamo-electric machines set in motion by steam-power, the same laws govern them all, and the discovery of these laws entitle their respective discoverers to the profoundest admiration for the zeal and perseverance by which only their noble results were obtained.

Amongst the many forms of dynamo-electric machines which have been introduced and successfully adopted for the purposes of illumination, besides that of Dr. Siemens, we may mention the Gramme machine, which furnishes the light on the Thames Embankment and Waterloo Bridge; the Brush, adopted at South Kensington Museum, the Great Eastern Railway, and a vast number of factories and important buildings in this country, and in the United States; and the Wilde machine, which has for some years past been adopted by her Majesty's navy.

The electric lamp, or *regulator*, is one of the most important features of the electric-lighting system; and indeed the success or failure of the new luminary depends greatly upon the perfection of this delicate piece of mechanism. The general principle upon which all electric lamps are constructed may be summarized in a few words. When the electric current leaves the machine in which it is generated it is conducted by copper wires to the electric lamp, in which two long pieces of carbon* are so arranged that they may approach each other with or without absolute contact. These carbons are kept at a certain distance from each other by means of clockwork, or other

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* These carbon points are frequently made from an incrustation which forms in the interior of gas-retorts; but there have lately appeared some excellent specimens which have been artificially manufactured.

suitable contrivance, the object being to keep the positive and negative points moving towards each other at the same rate of speed at which the carbons are consumed. The positive carbon burns away more rapidly than the negative, consequently the former requires to move somewhat quicker than the latter. In some forms of electric lamp the negative carbon is made a fixture, whilst the positive is made to move slowly and regularly in the direction of the negative as fast as the consumption of carbon necessitates.

In the Jablochkoff candle, as it is called (and which is adopted on the Thames Embankment), the two carbons are placed side by side, instead of being opposite each other as in most other systems, with an intervening layer of plaster of Paris or China clay (kaolin). The pair of carbons are connected at the top by a small piece of carbon, but with this exception, they are insulated by the layer of China clay. When acted upon by the electric current, the insulating medium consumes with the carbons, the aluminium contained in the kaolin becomes dissipated, whilst the silica fuses and falls down into the socket of the lamp.

In the Brush system a new form of dynamo-electric machine is introduced, as also a lamp of simple construction. The light produced by this system is exceedingly steady and devoid of colour—unlike the Jablochkoff candle, which frequently gives a rose-coloured light, and is liable to flicker.

The Siemens' regulator is an exceedingly perfect piece of mechanism, and in connection with his dynamo-electric machine is capable of yielding a powerful and steady light. The Siemens' system has been adopted on board some of the leading transatlantic steamers; in the library of the British

Museum, at the Victoria Extension Docks, and in a vast number of large manufactories at home and abroad.

Now that the Electric Light has passed through all the stages of trial necessary to establish its practicability as the light of the future, and with unquestionable success, there is reason to believe that in a very moderate space of time this means of illumination will be widely extended. Indeed if it were not for the time necessarily involved in the construction of the large number of machines and regulators already required for lighting factories, railway stations, and other important structures, it is probable greater evidence of the progress of the new light would be manifested. It is only a question of time, however, and a very few years may enable us to see all our principal thoroughfares lighted by electricity, as well as the chief public buildings. As gas was destined, some sixty years ago, to take the place of the old oil-lamp, so we may fairly expect that electricity will supplant gas as a luminant. When we consider the danger to which we are always exposed by the employment of that highly inflammable substance known as coal-gas, and the terrible nature of the explosions which have from time to time been caused by its ignition in the presence of atmospheric air, it becomes a duty to give every possible encouragement to the adoption of a less dangerous but far more effective illuminating medium. In a sanitary point of view, moreover, the electric light has every advantage over the noxious, and indeed poisonous, coal-gas. Again, the rays from an electric lamp, giving a pure white light, enable us to behold even the most delicate shades or tints of colour as perfectly as in the brightest light of day.

MANUFACTURE OF ALUM.

The ordinary alum of the shops is a sulphate of alumina and potash. It was first made in this country, during the reign of Queen Elizabeth, by Thomas Challoner. The principal alum-works are in Glasgow, Yorkshire, Newcastle-on-Tyne, and Manchester.

There are many methods of preparing alum from the native ores (schistose clays, aluminous shale, alum-stone, etc.) The *natural process*, as it is called, consists in placing the ore in large heaps, which are moistened with water, when it gradually becomes hot, and finally falls to a powder. If the ore does not become reduced to a powdery state by this means, it is calcined by being mixed with small coal and burned at a low heat. The heap is then covered with a layer of calcined or exhausted ore to protect the mass from wind and rain. After a while, and when the mass has become cool, it is again sprinkled with water. It afterwards assumes a porous condition, when the atmosphere is allowed to act freely upon it for some time. The action of moisture and air, which occupies from three to twelve months, renders the insoluble constituents of the ore *soluble* in water. The mass is then placed in large cisterns and mixed with water, the clear liquor being run into a stone cistern heated by a reverberatory furnace, where it becomes concentrated by evaporation. The liquor is then placed in coolers. After a while a green salt (sulphate of iron, or *copperas*) crystallizes at the bottom of the vessel. The mother-liquor (sulphate of alumina) is then run off into another cistern, and a saturated solution of chloride of potassium, or sulphate of

potash, added until it ceases to produce a milky precipitate, which is alum in the form of very fine crystals. When sufficient salt of potash has been added, the whole is allowed to repose until the deposition of the minute alum crystals is complete. The mother-liquor is drawn off as before, and the crystals are well drained to free them from the supernatant liquor. They are then washed with a small quantity of water, which is drained off as before, the operation being repeated with fresh cold water, and this again drained off.

The drained crystals are next dissolved in hot water and boiled in a leaden copper, and the clear liquor afterwards pumped or run off into large casks, when the alum crystallizes round the interior of these vessels. The hoops which bind the staves of the casks are removed at the end of about ten days, when the alum is found in the form of a crystalline mass corresponding in form and size to the interior of the cask in which the crystallization was effected. The uncrystallized salt is afterwards removed from the interior of the mass by punching several small holes near the bottom, when the mother-liquor flows out, and is collected for further evaporation and crystallization.

The alum crystals, when thoroughly drained, are then broken up and packed in casks, when they form the ordinary alum of commerce.

The *artificial process* of alum manufacture consists in treating aluminous clay with oil of vitriol, by which a solution of sulphate of alumina is obtained, and to this is afterwards added chloride of potassium, sulphate of potash, and (sometimes) sulphate of ammonia.

In carrying out the " artificial " process, certain clays are selected which do not contain oxide of iron, or carbonate

of lime. China clay is frequently used for this purpose. The clay is first calcined at a moderate heat, great care being taken to avoid too high a temperature, which, by *hardening* the clay, would render it impracticable in the after treatment. When properly calcined the clay is powdered and sifted, and is then treated with about half its weight of sulphuric acid in a stone or brickwork basin, with furnace fire so arranged that the heat plays equally over the surface of the liquor. This operation is kept up for several days, when the mass is removed and set aside for a few weeks in order that the acid may have time to act freely upon the alumina. At the end of some six or eight weeks the sulphate of alumina formed is washed out and the solution evaporated, after which the salt of potash, or ammonia, is added. When the latter is used, the resulting alum is called "ammonia alum," whereas the former is known as ' potash alum."

Roman alum, or Roche alum, is a native salt, of a slightly reddish colour, imported from Civita Vecchia. It is frequently imitated, in colour, by tinting ordinary alum with Venetian red or other colouring matter.

In the arts alum is employed very extensively, especially in the operations of dyeing, in which it is used as a mordant. When solutions of soda and alum are mixed, a delicate gelatinous precipitate is formed, which when filtered, washed, and dried forms a beautiful white powder —*hydrate of alumina*. This forms the basis of cobalt blue, lake pigments, and many other delicate colours.

CHLORIDE OF LIME, OR BLEACHING POWDER.

This useful disinfectant and bleaching agent is very easily prepared. A quantity of recently-slaked lime (hydrate of lime) is placed in a suitable vessel, and a stream of chlorine gas passed through it until the lime ceases to absorb the gas. A retort is charged with oxide of manganese, sulphuric acid and salt, or hydrochloric acid, when chlorine gas becomes freely disengaged. The gas is passed through water, and conveyed by leaden pipes to a chamber in which are arranged shelves, having each a quantity of slaked lime placed upon them. When the lime has absorbed as much chlorine as it is capable of doing, it is carefully removed and placed in casks for sale. During the operation it is usual, when a really good article is required, to stir the lime frequently so as to expose fresh surfaces to the action of the gas. It is also usual, in the manufacture of bleaching powder, to keep the materials at a rather low temperature, so as to prevent the escape of the absorbed chlorine.

Chloride of lime is much used as a bleaching agent for textile fabrics, and also for whitening the materials with which inferior papers are made. As a disinfectant and deodoriser, chloride of lime may be considered one of the most effective agents, if not the most powerful, known.

PHOSPHORUS.

This remarkable substance is manufactured, on the large scale, from bones. The bones are first calcined, and the ashes are then reduced to powder by grinding. The bone-

ash is first mixed up into a paste with water; oil of vitriol is then added gradually, with constant stirring. After some hours the mass is diluted with water, and heated in a leaden vessel until it loses its granular appearance; it is afterwards placed in a cask and treated with a large quantity of cold water. The clear liquor is next run off and boiled until a white deposit of sulphate of lime is formed abundantly, this is then set aside until cold, when the clear water is again run off, and this is afterwards evaporated to a syrupy consistence. Dried powdered charcoal is then added and the mass dried in an iron pot at a heat below redness. It is then well covered up and allowed to cool.

When quite cold the dried mass is placed in stone retorts, carefully luted, and moderate heat applied. A tube is connected to the beak of the retort, which is allowed to dip into lukewarm water. The impure product which distils over is afterwards purified by pressing it through chamois leather *under warm water*. It is then melted under water and cast in moulds, which are generally glass tubes. These tubes are then placed in cold water until the phosphorus becomes solid, when it is pushed or dropped out of the tubes into bottles containing cold water.

In describing the manufacture of this interesting elementary substance, Ure says:—

" The heat of the furnace should be most slowly raised at first, but afterwards equably maintained in a state of bright ignition. After three or four hours of steady firing, carbonic acid and sulphuric acid gases are evolved in considerable abundance, provided the materials had not been well dried in the iron pot; then sulphuretted hydrogen makes its appear-

ance, and next phosphuretted hydrogen, which last sɛ
continue during the whole of the distillation. . . . The fin
should be regulated by the escape of this remarkable gas
which ought to be at the rate of about *two* bubbles per second.
If the discharge comes to be intercepted, it is to be ascribed
either to the temperature being too low, or to the retort
getting cracked; and if upon raising the heat sufficiently no
bubbles appear, it is a proof that the apparatus has become
defective, and that it is needless to continue the operation.

"We may infer that the process approaches its conclu-
sion by the increasing slowness with which the gas is dis-
engaged under a powerful heat; and when it ceases to
come over we may cease firing, taking care to prevent
reflux of water into the retort" (and consequent explosion),
"from condensation of its gaseous contents, by admitting
air into it through a recurved glass tube, or through the
tube of the copper adapter. . . . The usual period of the
operation, upon the *great scale*, is from twenty-four to
thirty hours."

The principal use of phosphorus is in the manufacture
of lucifer matches.

MANUFACTURE OF GLASS.

It is supposed by some that the invention of glass was
purely accidental, and indeed there is every probability
that such was its origin. Pliny states that a merchant
vessel laden with crude soda (*natron*, as it was called) being
driven upon a sea-coast in tempestuous weather, the crew
were compelled to cook their meals ashore; they placed
lumps of natron upon the sand as supports for their cook-
ing utensils, and afterwards were surprised to discover

rangins of solid transparent stone among the embers.   The
feeteous mass was glass.

ce The manufacture of window-glass was first commenced
in England in the year 1557, in Crutched Friars, London.
The first specimens of blown glass were made in Lambeth
in 1673.

Glass is essentially a compound of silica (sand or flint),
soda, or potash, and lime, or some metallic oxide, as oxide
of lead, for instance.   When silica and soda, or potash, are
fused together in certain proportions the resulting sub-
stance is called *soluble glass*, from the fact that it is soluble
in water.   All other kinds of glass are hard, brittle, gen-
erally transparent, and perfectly unacted upon by water,
unless an excess of either alkali be present.

Bottle-glass was formerly made from soapmakers'
waste (the insoluble refuse of kelp, or crude soda) and
river-sand.   It is now manufactured from yellow sand,
kelp, wood-ashes, pale clay, and "cullet" (broken glass);
or from pale sand, lixiviated—that is, washed—wood-ashes,
pearl-ash, common salt, white arsenic, and charcoal.   This
makes a pale-green glass.   Yellow bottle-glass is made by
the addition of a little black oxide of manganese.

Broad glass, or **spread window-glass,** is made from
white sand, dried sulphate of soda (Glauber's salt), pow-
dered charcoal, cullet, and peroxide of manganese ; or
white sand, potash, common salt, peroxide of manganese,
and pale cullet.   This represents the ordinary window-
glass of commerce.

Crown glass is made from finest white sand, purified
potash, white arsenic, lime, and oxide of manganese; or
pure sand, dry sulphate of soda, quicklime, and powdered
charcoal.

Crystal glass is prepared from the finest Lynn' sand, calcined, sifted and washed, oxide of lead, refined pearl-ash, nitre, arsenious acid, and peroxide of manganese.

Optical glass is manufactured from the purest quartz, red-lead (minium), purified potash, and purified nitre.

Plate glass is made from the finest white sand, dried carbonate of soda, lime, nitre, plate-glass cullet (broken plate glass), peroxide of manganese, and a little cobalt azure. This is ordinary English plate glass.

In manufacturing glass, certain pots, or crucibles, are employed, and these are made of refractory—that is, infusible—clay, called *shale* or *slate-clay*, found largely in the neighbourhood of Stourbridge. This clay is a silicate of alumina, and will bear the heat of a very powerful furnace without undergoing fusion. The clay is first ground to a fine powder, and this is afterward kneaded into a thick paste. The pots are then fashioned into the required form, and are then very carefully dried, after which they are *annealed*, as it is termed, at a red heat, for four or five days. They are then set in their proper position in the fire, and this requires to be done with great caution owing to the intense heat of the furnace. Referring to the operation of removing faulty pots and replacing them by new ones, Dr. Ure says, "It is frightful to witness the eyes and fuming visages of the workmen, with the blackening and smoking of their scorched woollen clothes, exposed so long to the direct radiations of the flame. A light mask and sack dress, coated with tinfoil, would protect both their faces and persons from any annoyance, at a cheap rate." These feeling observations, and the concluding happy suggestion, are alike worthy of the late eminent chemist.

Glass-houses are generally constructed of a conical form,

ranging from 60 to 100 feet in height, and from 50 to 80 feet in diameter at the base. The furnace is built in the centre of the area, above an arched gallery extending across the whole building, through its walls, each aperture being fitted with folding doors. The centre of this vaulted arch is left open, and is covered over by the grate-bars of the furnace. Surrounding the furnace is a platform constructed with firebrick, upon which the pots are placed. These are removed, as occasion requires, through holes in the walls of the building; the materials are also shovelled in through these apertures

In describing the operation of bottle-glass making, Ure says, "It is hardly possible to convey in words alone a correct idea of the manipulations necessary to the formation of a wine-bottle; but as the manufacturers make no mystery of this matter, any person may have an opportunity of inspecting the operation. Six people are employed at this task. One, called a gatherer, dips the end of an iron tube, about 5 feet long, previously made red-hot, into the pot of melted *metal*, turns the rod round so as to surround it with glass, lifts it out to cool a little, and then dips and turns it round again; and so in succession till a ball is formed on its end sufficient to make the required bottle. He then hands it to the blower, who rolls the plastic lump of glass on a smooth stone, or cast-iron plate, till he brings it to the very end of the tube; he next introduces the pear-shaped ball into an open brass or cast-iron mould, shuts this together by pressing a pedal with his foot, and holding this tube vertically, blows through it so as to expand the cooling glass into the form of the mould. Whenever he takes his foot from the pedal-lever the mould spontaneously opens out into two halves, and

falls asunder by its bottom hinge. He then lifts the
bottle up at the end of the rod, and transfers it to the
finisher, who, touching the glass tube at the end of the
pipe with a cold iron, cracks off the bottle smoothly at its
mouth-ring. The finished bottles are immediately piled
up on the hot annealing arch, where they are afterwards
allowed to cool slowly for twenty-four hours at least."

In making British sheet glass, the materials are first
converted into what is technically called a *frit*—that is,
into a powdery condition, and not fused. This operation
occupies many hours, and is conducted in a reverberatory
furnace, with constant stirring (to prevent fusion), with
long-handled rakes and shovels. The *frit* is then removed
by means of shovels to the melting-pots, and is again sub-
jected to heat until fusion takes place. When in the
proper condition, the *metal*, as it is termed, is lifted out of
the pots by iron tubes, blown into *pears*, which are then
elongated into cylinders. These are then *cracked* the whole
length of one side by passing a cold iron, previously dipped
in water, on the surface. The cylinders are then opened
out into the form of sheets. A spreading furnace is em-
ployed for converting the cylinders into flattened sheets or
plates, and the heat has to be so regulated as to soften the
" metal" without melting it.

Glass plates are formed by first blowing the metal into
an oblong cylinder, of the length required for each sheet
or plate, and of a diameter proportioned to the required
width of the extended plate. A hole is then made in the
extreme end of the cylinder, or pear; this opening is
afterwards extended by means of a pair of spring tongs,
the glass being turned upon its axis during the operation :
by this means the opening at the end of the cylinder be-

comes widened. The blown end of the cylinder is next cracked off, and the glass turned to the fire to be again softened, after which its narrow end is widened like the opposite end, whereby the cylinder becomes equalized; it is then either cracked down its side by an iron rod dipped in cold water or is divided by shears. It is then placed upon a copper plate, heated, and spread out flat, after which it is annealed.

Flint glass is produced from the finest Lynn sand, calcined, sifted, and washed. Red-lead or litharge, and pearl-ash form the third ingredient, while nitre is employed as a fourth to decompose any combustible matter that may accidentally be present. The potash must always be purified before being employed in the manufacture of this beautiful glass. Arsenic and manganese are sometimes introduced, in small quantities, to purify the colour and increase the transparency of the glass. Manganese is only used in minute quantities, otherwise it imparts a purple tint; and if an excess of arsenic is used, the glass is apt to become opalescent.

It is usual, in making flint glass, to mix with the ingredients a certain amount of broken glass of the same quality. The mixture is put into the pots by means of a shovel, and when it becomes melted a further supply is added, and so on until the pot is quite full. When the melting is complete, the floating impurities are skimmed off, and the mouth of the pot is then closed. Flint glass requires at least forty-eight hours' heating in the furnace to complete the process of vitrification. When upon examination the glass appears clear and free from air-bubbles, the heat of the fire is somewhat reduced in order that the glass

may settle.   When required to be worked, the temperature of the metal is slightly raised.

Coloured glass is produced by adding to it, while in a melted state, certain metallic oxides.   For example, oxide of cobalt yields a *blue* colour; black oxide of copper, *green;* oxide of manganese, an *amethyst* tint; oxide of iron, *brown;* suboxide of copper, *ruby-red;* oxide of gold, *purple;* oxide of tin, *white;* oxide of silver, *yellow.*   Sometimes these colouring materials are placed in a thin layer upon the surface of the glass object, and heat applied until the coloured compound fuses.

Glass vessels in which the inner surface is colourless and the external prominences coloured, are made by dipping the blowpipe-rod (employed in glass-blowing) first into a pot of melted *colourless* glass, which is then blown into a bulb of the required size, and when this has cooled a little, it is dipped into the *coloured* glass for an instant. The respective layers of glass become attached without blending.   When the article is fashioned to the required form, it is cut to a depth sufficient to lay bare the colourless stratum beneath.   Designs of any pattern may thus be formed, in which the external facets will be coloured and the rest of the object colourless.   Many beautiful specimens of Bohemian glass are thus produced.

Although there are many other important varieties of glass, and all of which are highly interesting as regards their methods of manufacture, it is hoped that the little insight into this famous industry which we have given will induce the reader, should he desire a further knowledge of the art, to refer to more elaborate treatises upon the subject.

OXALIC ACID.

This acid is found in Nature both in the vegetable and mineral kingdoms. It abounds, in combination with potash, in the plant known as *wood-sorrel*. Oxalic acid may be formed artificially by acting upon starch, sugar, woody fibre, etc., with nitric acid. There are many processes for manufacturing the acid for commercial purposes from which the following may be selected:—

Potatoes are reduced to a pulpy consistence and boiled for several hours with a small quantity of water in a leaden vessel, with the addition of strong sulphuric acid, which converts the potato fecula into saccharine (or sugary) matter. The mass is afterwards filtered through hair sieves or strainers, and the clear liquor evaporated to a certain degree of concentration. Nitric acid is then added, which converts the product into *oxalic* acid.

Another patent process, and one which is much used, consists in treating woody fibre by fusion with caustic alkali, the discovery of which is due to the great French chemist Guy-Lussac. Dr. Murray Thomas, of Edinburgh, thus describes the process of manufacture:—

"1. *Hydrate of soda* and *hydrate of potassa*, mixed in the proportion of two equivalents of the former to one equivalent of the latter, are dissolved, and the solution evaporated until of the specific gravity 1·35; *sawdust* is now stirred in until a thick paste results. 2. This paste is then heated on iron plates, during which it is constantly stirred; water is at first given off, the mass then swells, and inflammable gases, hydrogen and carburetted hydrogen, are evolved along with a peculiar aromatic odour. When

the temperature has been maintained at 400° for one or two hours, this stage of the process is complete; the mass has now a dark colour, and contains only 1 to 4 per cent. of oxalic acid, and about ·5 per cent. of formic acid. The bulk, therefore, of the mass at this stage consists of a substance whose nature is not yet known, but which is intermediate between cellulose and oxalic acid. 3. The next stage consists in a simple extension of the last, in which the mass is heated till quite dry, care being taken that no charring takes place. It now contains the maximum quantity of oxalic acid, 20 to 30 per cent. 4. This oxalic acid is now combined with both potassa and soda in the grey powder resulting from stage 3. This powder is now washed on a filter with *solution of carbonate of soda,* which seems to have the singular and unexpected power of decomposing the oxalate of potassa and converting it into oxalate of soda. At all events, it is quite true that all traces of potassa are washed out with the solution of carbonate of soda. The only explanation that occurs to account for this unusual decomposition is that oxalate of soda is a more insoluble salt than oxalate of potassa, and therefore may be formed by preference. 5. This oxalate of soda is now decomposed by *boiling milk of lime.* Oxalate of lime falls as a precipitate, and soda remains in solution. This soda is boiled down and again made use of with fresh *sawdust.* This recovery of alkali is also practised with the potassa salt which filters through in the last stage. 6 The oxalate of lime is now decomposed in leaden vessels with sulphuric acid. Sulphate of lime is precipitated, and oxalic acid is in solution, which is now evaporated, and the acid separates in crystals, which now need only to be recrystallized to make them quite pure, and fit the acid for

all the purposes for which it is employed." By this ingenious process 2 lbs. of sawdust are made to yield 1 lb. of oxalic acid.

CARBOLIC ACID.

This popular antiseptic is one of the products resulting from the destructive distillation of coal. Crude coal-oil is placed in a still, and the product, which passes over at a temperature of from 300° to 400° Fahr., is mixed with a hot solution of caustic potash. After a while, a pasty, semi-crystalline mass is formed, and this is allowed to repose, the clear liquor which rises to the surface being afterwards poured off The solid matter is next agitated with a small quantity of water, in which it becomes dissolved. This solution separates into two products, the heavier of which contains *carbolate of potassa*, a compound of carbolic acid and potash. The clear liquor is next decanted, and the denser portion is treated with hydrochloric acid; a solution of carbolic acid now rises to the surface, which is afterwards treated with chloride of calcium, a substance having a great affinity for water. The product is next purified by distillation, and is obtained in crystals by rapid cooling. The crystals are afterwards dried and kept carefully excluded from the air.

The ordinary carbolic acid of commerce is a very impure article, chemically speaking, but as a deodorizer and antiseptic* it is undoubtedly useful. As a disinfectant, however, it is questionable whether it should be relied upon. It is one thing to disguise an offensive odour by one more powerful than itself, and another to destroy the germs

* That is, having the power to arrest putrefaction.

of an infectious disease. It is more than probable that chlorine, or hypochlorous acid, disengaged from chloride of lime, would be more dependable than carbolic acid.

DISTILLATION.

The art of manufacturing intoxicating liquors, or spirits, consists essentially of four distinct operations, namely, *mashing, cooling, fermenting*, and *distilling*. It appears that the art of obtaining alcohol from fermented vegetable matter was unknown to the ancient Greeks and Romans, and yet they did very well, and sometimes very badly, without it. The discovery of the art of manufacturing spirituous liquors seems to have begun in the north of Europe, and to have been handed down to the more southern parts of the globe by the writings of one Arnoldus de Villa Nova, who declared the " essence of wine" to be "an emanation of the Divinity, an element newly revealed to man, but hid from antiquity, because the human race were too young to need this beverage, destined to revive the energies of modern decrepitude. He further imagined that the discovery of this *aqua vitæ*, as it was called, indicated the approaching consummation of all things—the end of the world. However much he erred as to the value of this remarkable essence, he truly predicted its vast influence upon humanity, since to both civilized and savage nations it has realized greater ills than were threatened in the fabled box of Pandora" (Ure).

Whisky derives its name from *usquebaugh*, an Irish word. The best, or "rale Irish," whisky is made from malted barley, mashed, fermented, and distilled. Inferior qualities are made from " raw grain," with sometimes the

addition of a little malt.   Potatoes mashed with a little malt are also employed in making inferior whiskies.

Scotch whisky of the best quality is made from malted grain, but " raw"—that is, unmalted—oats and rye are frequently used to produce a cheaper and inferior article.

Gin, or **geneva,** is manufactured from corn spirit, flavoured with either oil of juniper or oil of turpentine. Formerly gin was imported from Holland in the form of an agreeable, mellifluous spirit, flavoured with juniper berries, from which the name of geneva, or *genèvre* (the French for juniper), was derived.   The word " gin" is a corruption of the first syllable of *geneva*

In making English gin a certain quantity of clean corn spirit at proof is taken, and to this is added rectified oil of turpentine and culinary salt, dissolved in water.   These are well agitated together, and the product placed in a still. When in the process of distillation the *faints* begin to rise, the operation is stopped.

In flavouring English gin many substances are employed, as oil of caraway, oil of sweet fennel, essence of lemons, cardamoms, essential oil of almonds, creosote, cassia, fusel oil, crude pyroligneous acid, and many other volatile substances more or less palatable and pernicious.

In the admixture of certain foreign matters, as flavourings, with gin, it would be well if the Government had a voice ; and even if the distiller were permitted to flavour his gin moderately with aromatic and other matters of a comparatively harmless character, the " line" ought to be drawn at this point.   It is hardly fair to the public that ignorant and crafty retailers should be permitted to add anything they please to their liquors by which their cus-

tomers may be more or less injured in health. "All spirits sold at this establishment are polluted" might be appropriately substituted by some unprincipled retailers for the well-known label so prominently thrust before the public eye after one or two small prosecutions for adulteration had been instituted against the vendors of *rather* too dilute liquor!

Rum of an inferior quality is made from the fermented skimmings of the sugar-boilers, the drainings of sugar-pots and hogsheads; or molasses, with the addition of cane juice; or wort made by mashing the crushed cane. The sweet liquor thus obtained is afterwards fermented and the spirit obtained by distillation.

Jamaica rum is made by mixing the skimmings of the sugar-house, molasses, and fresh cane juice, the whole being fermented and subsequently distilled from copper stills The flavouring principles are mostly due to the cane juice and the skimmings of the clarifier. The fermentation is conducted in very large vessels, and occupies from nine to fifteen days. When the fermented wash has reached its highest point, it is promptly transferred to the still in order to prevent *acetification* About 115 gallons of proof rum are obtained from 1200 gallons of wash. Three hogsheads of sugar yield about 200 gallons of rum. Cane juice contains from 12 to 16 per cent. of raw sugar, and, like grape juice, it readily ferments without the aid of yeast.

The art of distillation, as practised in this country, consists first in forming the mash. Barley and raw grain, as oats, rye, wheat, Indian corn, etc., are first ground to a meal by millstones. When 40 bushels of barley and 20 bushels of oats form one mash, from 600 to 700 gallons of

water at 150° Fahr. are added. These are worked up in the mash-tun with wooden oars, or, in the larger distilleries by machinery set in motion by steam-power. After a few hours about 400 gallons of water at a temperature of 190° Fahr. are added.

The wort is examined from time to time, and when it has attained its maximum degree of sweetness (which is determined by a "saccharometer") it is drawn off from the grains and subjected to the process of fermentation. A certain proportion of yeast is added to the wort, and this is generally the best top "barm" of the London breweries About 1 gallon of yeast is required for every 2 bushels of meal and malt contained in the mash. When the fermentation appears to diminish in vigour, fresh yeast is added to accelerate the process, which occupies from nine to twelve days, or even longer, with considerable augmentation of temperature until after the fourth day.

When the fermentation is complete, the wort is transferred to the still, and the spirit carefully run off. While distillation is progressing, the spirit is tested from time to time by a *hydrometer*, an instrument for measuring the density or strength of the spirit. When all the spirit has distilled over, the "spent wash" is removed. The strongest spirit passes over first, and this is received in one vessel, while the subsequent runnings, which are weaker in spirit, are received in separate vessels.

The lower the temperature at which the spirit comes over, the greater percentage of alcohol it contains, and the less quantity of volatile oils will pass over with it. Very strong spirit of wine, as it is called, is obtained by repeated rectifications and distillations.

Brandy is obtained by distillation from the wine of

grapes. Like other spirits, it is colourless when first distilled, but when stored in casks it acquires a yellow tint from its action upon the wood of the casks. This constitutes what is called *pale brandy*. Burned sugar (caramel) is employed to heighten the colour, when it becomes the *brown brandy* of the shops.

Pure brandy is essentially a solution of alcohol in water, with small quantities of volatile oil, acetic acid, acetic ether, colouring matter, tannin, etc. The French brandies imported into this country do not much resemble the article usually imbibed under the title of *eau-de-vie* on the Continent. Indeed, to suit the vitiated taste of Mons. J. Bull it is a common practice to add spirit of wine and colouring matter to brandies "made up" specially for that gentleman. The finest Cognac brandy is obtained by careful distillation from pale white wines.

British brandy used formerly to be made from spoiled wines, wine-dregs, beer-bottoms, and other grateful substitutes for the juice of the grape. At the present time molasses, spirit, and malt do duty for the above refuse. The following formula will give the reader an idea of how many interesting materials his glass of brandy-and-water is composed, if he be not fortunate enough to obtain the genuine Cognac: Finest malt spirit, at proof, 12 gallons; water, 5 gallons; crude tartar, or wine-stone, ¾ lb. (previously dissolved in boiling water, 1 gallon); acetic ether, 6 fluid ounces; French wine-vinegar, two quarts; French plums, bruised, 5 lbs.; sherry wine-bottoms, ½ gallon. Mix in a fresh-emptied sherry or French brandy cask, and let them stand together for fourteen days (or better, for a month), frequently "rummaging up" the liquor with a stick; next draw over 15 gallons of the mixture from a

still furnished with an agitator, put the "rectified" spirit into a clean fresh-emptied Cognac brandy cask, and add of tincture of catechu 1 pint, oak shavings, fresh and clean, 1 lb., and spirit colouring (about) ¾ pint. Agitate occasionally for a few days, and then let it repose for a week, when it will be fit for use (!). Product, 15 gallons of brandy 17° under proof. Age greatly improves it (Cooley).

PROTOCHLORIDE AND PERCHLORIDE OF TIN.

The **protochloride of tin** is formed by digesting granulated tin in hot hydrochloric acid until hydrogen gas, at first rapidly evolved, ceases to escape In order to obtain a neutral solution, an excess of tin must be present in the dissolving vessel. For making small quantities of this salt, a Florence oil-flask, previously well cleaned, to free it from greasy matter, is a very convenient vessel. When the solution is evaporated with care, beautiful needle-like crystals are formed

Perchloride, or **bichloride, of tin** is made by dissolving grain tin in *aqua regia* (hydrochloric acid, two parts; nitric acid and water, of each one part, by measure). The tin must be added gradually, and each portion allowed to dissolve before adding more, otherwise the chemical action is liable to become violent, and the perchloride deposited at the bottom of the vessel.

Solutions of perchloride of tin are much used by dyers, as mordants, in their operations.

CHLORIDE OF GOLD.

Gold is very readily soluble in two parts hydrochloric acid, and one part nitric acid (*aqua regia*). In order to obtain the salt as neutral as possible the following plan has been adopted by the author in making large quantities of chloride of gold for various purposes, and this may be practised in a small scale as follows: Take, say, half an ounce of fine grain gold, and place it in a clean Florence oil-flask. Now pour on a mixture of nitric and hydrochloric acids in the above proportions, but less than sufficient to dissolve the whole of the gold. The application of gentle heat is necessary to set up chemical action vigorously. Dense red fumes are given off, which fill the interior of the flask: after a while these fumes cease, when, provided some gold remains undissolved, the solution is to be poured into an evaporating dish and heated over a sand-bath until a dark-red semi-fluid mass results. If now the evaporating dish be moved round and round so as to cause the concentrated solution to spread over a large surface of the dish, and the heat kept up, the chloride will eventually assume a dense blood-red colour, which on cooling becomes solid and crystalline. The heat must not be too great at this period, or the gold will become reduced to the metallic state. With moderate care a very fine preparation of terchloride of gold may be thus prepared, which is admirably suited for photographic operations, for making the purple of Cassius, and for many other useful purposes. Chloride of gold prepared in this way is infinitely more active in the toning of photographic proofs than the ordinary chloride of gold of commerce, and will do at least five times as much work.

PURPLE OF CASSIUS.

This beautiful pigment is much used in staining glass and porcelain a red or purple hue. It requires the utmost care in its preparation, otherwise failure is certain even with the most skilful manipulators. The pigment is prepared by adding to a perfectly neutral solution of terchloride of gold (see p. 140) protochloride and perchloride of tin. Neither of these salts alone produce the required purple precipitate from the solution of gold, but when both are employed in proper proportions the important result is readily obtained. One part crystallized *protochloride* of tin, and two parts crystallized *perchloride* of tin, added to one part of neutral chloride of gold, yield a beautiful purple precipitate called the *purple of Cassius*. When the protochloride of tin is in excess, a yellow, blue, or green tint is obtained, while an excess of the perchloride gives a red or violet hue.

M. Buisson prepares this colour by first dissolving 1 gramme of pure tin in hydrochloric acid, forming a perfectly neutral solution. He then dissolves 2 grammes of tin in *aqua regia* (three parts nitric acid to one part hydrochloric acid), and finally 7 grammes of fine grain gold in six parts of hydrochloric acid and one part nitric acid, taking care to make the solution neutral. This solution of gold is afterwards diluted with about 3 quarts of distilled water. The whole of the solution of perchloride of tin is then added, and afterwards the protochloride is added, drop by drop, until the precipitate acquires desired purple tint. The precipitate is then repeatedly washed and dried at a very gentle heat.

GALLIC ACID.

This is a crystalline substance obtained *indirectly* from gall-nuts and other vegetable productions which contain *tannin* or *tannic acid*. It appears, in fact, to be a result of the action of the oxygen of the atmosphere upon tannin. Dumas' process for its manufacture is: Powdered nut-galls, moistened with water, are exposed to the action of the air, in a warm situation (at a temperature of 70° or 80° Fahr.) for several months, fresh water being added occasionally to make up for loss by evaporation. The dark-coloured mass which remains at the end of that time is pressed in a cloth, and the solid matter then boiled in a large quantity of water.

The solution, filtered while still hot, deposits, on cooling, crystals of *gallic acid*. The acid may be purified by redissolving the crystals and filtering through animal charcoal, and subsequently re-crystallizing.

FREEZING MIXTURES.

The production of intense cold without the aid of ice or snow is not only an interesting scientific fact, but may be rendered serviceable to various useful purposes in the ottest climates The following interesting tables were piled by Mr. Walker as far back as 1808, from actual iments made by himself.

Table III. is given a series of formulæ for producing cold by chemical agents alone.

Pure white enamel.—The beauty of this delicate substance depends upon its being absolutely free from any shade or tint of colour; it must be a pure *dead white*. The materials employed in making this enamel must therefore be the purest obtainable. White enamel may be prepared by making a *calcine* with 2 parts of tin to 1 of lead, calcined as before described. The united oxides of tin and lead thus formed are melted with 2 parts of fine crystal and a small portion of manganese, the ingredients being previously well ground together. After being fused, this frit is poured into water, and is afterwards dried and remelted. Sometimes antimoniate of potash is employed in making white enamel, in place of the oxides of tin and lead, by fusion with ordinary glass

Blue enamel is obtained from the oxide of cobalt, or from some salt of that metal. The beautiful azure blue which oxide of cobalt imparts to enamels renders it one of the most important substances employed by the enamel manufacturer. In making this enamel the following materials are sometimes employed: White sand, red-lead (minium), and nitre, of each 10 parts, oxide of cobalt, 1 part, more or less, according to the depth of colour required. White frit, or flux, and oxide of cobalt produce a vivid blue enamel.

Green enamel.—Frit or flux, 8 ounces; black oxide of copper, $\frac{1}{4}$ of an ounce; mixed and fused, yield a rich green enamel A finer green is however obtained by adding to *transparent frit* a suitable quantity of oxide of chromium. Blue and yellow enamels fused together produce various shades of green, according to the proportions employed.

Olive enamel may be obtained by uniting blue enamel, 2 parts; black and yellow enamels, each 1 part.

Brown enamel —Powdered flint, 8 parts; red-lead, 16 parts; manganese, 5 parts.

Purple enamel is obtained by adding to ordinary frit, or flux, oxide of gold, purple of Cassius (a combination of gold and oxide of tin, see p 141), or peroxide of manganese.

Red enamel.—The frit is combined with the red oxide or peroxide of copper, and if a green or brown colour results, charcoal or tallow are added, when the desired colour is produced. Oxide of gold, or the purple of Cassius, produces various shades of red, of a crimson or purple tint. A *dark red* is produced by adding to the flux calcined sulphate of iron and peroxide of iron

Rose-coloured enamel may be formed by mixing purple enamel, or its components, 3 parts; frit, or flux, 90 parts; oxide of silver, or leaf-silver, 1 part.

Violet enamel is formed by blending frit, 6 parts red enamel, 3 parts, and purple enamel, 2 parts

Yellow enamel.—Frit fused with oxide of lead, to which is added a little red oxide of iron (colcothar). Or white oxide of antimony, alum, and sal-ammoniac, of each 1 part; carbonate of lead, 1 to 3 parts. The ingredients are first reduced to a powder, then mixed, and exposed to heat sufficient to expel the sal-ammoniac. This gives a bright yellow.

Yellow enamels may be obtained by adding to the metallic fluxes pure oxide of silver Clouet says that when a thin film of oxide of silver is spread over the surface of the enamel to be coloured and exposed to a moderate heat, then withdrawn, and the film of reduced silver on the surface removed, the part beneath will be found tinged a fine yellow.

Orange enamel.—Red-lead, 12 parts; powdered flint, 3 parts; red sulphate of iron and oxide of antimony, of each 1 part Mix and calcine, and then reduce to a fine powder; lastly, mix with 50 parts of *flux*, and fuse as usual.

Black enamel.—Protoxide of iron, 12 parts, oxide of cobalt, 1 part; mixed and added to an equal weight of white flux, and fused as before. Or, according to Clouet, a fine black may be obtained by taking pure clay, 3 parts; protoxide of iron, 1 part.

JEWELLERS' ROUGE.

This is a delicate preparation of the peroxide of iron, and is ordinarily made by calcining sulphate of iron (green copperas) at a red heat, by which the sulphuric acid and water with which it is combined become expelled, and the peroxide of iron which remains is well washed to remove traces of acid, and afterwards elutriated to separate the finer particles, which are then allowed to subside. The deposit which results is then strained, dried, and reduced to a powder. Another process for making rouge is to precipitate a persalt of iron with potash or ammonia, when the oxide of iron is thrown down in the form of a hydrated peroxide, which is afterwards washed, dried, and heated until its combined water is expelled; the resulting product is of a brown-red colour, and is much used for silver and gold polishing, for polishing electroplate, glass, etc.

The following ingenious method of preparing rouge was suggested by M Vogel, jun., of Munich, and deserves reproduction :—

"Into a solution of sulphate of iron made with boiling water and filtered, pour a concentrated solution of oxalic

acid, until no more yellow precipitate of oxalate of protoxide of iron is formed. When the liquid is quite cold, and deposits nothing more, the precipitate is washed on a cloth with hot water until the washing water no longer gives an acid reaction upon blue litmus-paper. The oxalate is afterwards well drained, and heated in the partially dry state on an iron plate or in a boiler of the same metal, over a small charcoal-fire or even a spirit-lamp. The decomposition commences at the temperature of 392° Fahr., and on raising the temperature a little the red oxide of iron is formed, and is found in the finest possible state.

"The rouge thus formed affords the most perfect security of the finest division of the product, and may be employed with the greatest success in polishing either gold or silver, and it has been found invaluable in the polishing of plate-glass, daguerreotypes, and optical instruments."

MANUFACTURE OF INKS.

Black ink.—Ordinary black ink is essentially a decoction of nut-galls, to which sulphate of iron (green copperas) and gum are subsequently added. Good black ink may be made from various formulæ, but the following may be reckoned amongst the best of them :—

1. Aleppo galls, bruised, 4 ounces; soft water, 1 quart. Macerate for about ten days in a corked bottle with occasional agitation; then add gum-arabic $1\frac{1}{4}$ ounce (dissolved in a small quantity of water), and lump sugar $\frac{1}{2}$ ounce. Mix these ingredients well, and afterwards add powdered sulphate of iron $1\frac{1}{2}$ ounce. Agitate occasionally for a few days, when the ink may be decanted or strained for use.

2. Aleppo galls, bruised, 12 lbs.; soft water, 6 gallons   Boil for an hour, adding water occasionally to make up for loss by evaporation; afterwards strain, and again boil the galls with 4 gallons of water for half an hour.   Again strain the liquor, and boil a third time with $3\frac{1}{2}$ gallons of water and strain   Mix the several liquors thus obtained, and while still hot add sulphate of iron $4\frac{1}{2}$ lbs., and gum-arabic, powdered, 4 lbs   Agitate well until the latter ingredients are dissolved, and finally strain through calico or a hair sieve.   This formula will make about 12 gallons of good ink.

3 Galls, 4 lbs., logwood, 2 lbs.; pomegranate seed, 1 lb.; water, 5 gallons   Boil as before and strain.   When cold add to the liquor gum-arabic 1 lb., white sugar $\frac{1}{4}$ lb., dissolved in 3 pints of hot water.

4. Boil together galls 6 ounces; sulphate of iron and gum-arabic, of each 4 ounces; soft water 3 quarts.

5. Galls, 12 lbs., green copperas, 5 lbs., gum Senegal, 5 lbs.; water, 12 gallons.   The galls must be well bruised, and boiled for about three hours in three-fourths of the quantity of water given, and to make up for loss by evaporation during the boiling process, additional water must be added.   This decoction of galls is then to be placed in a tub and allowed to settle, when the clear liquor may be drawn off and the dregs placed upon a strainer.   The gum is to be dissolved in a small quantity of hot water, and the solution added to the decoction.   The green copperas is also to be dissolved separately, and the solution added to the above.   Immediately after the green copperas is added, the characteristic blackening occurs, which increases in intensity by the action of the air.   It is better, however, to keep the ink carefully excluded from the air by bottling;

and although the ink is much paler under such circumstances, it has a more permanent effect as a stain upon paper, inasmuch as it makes a deeper impression upon the fibre of the paper, which becomes blacker in a short time after using. It is the practice in some ink-factories to allow the ink to become mouldy on the surface, and then to decant the clear liquor. This is done to prevent the ink from becoming mouldy after it gets into the consumers' hands It is said that a few bruised cloves, oil of cloves, or other aromatic perfume, will check the tendency to . mouldiness; a few drops of creosote or carbolic acid dissolved in strong vinegar or spirit has also been suggested.

Dr. Wollaston's formula for good black ink is: Galls, 1 ounce; sulphate of iron, 3 drachms; gum-arabic, ¼ ounce; cold water, ½ pint. The whole of these ingredients must be placed in a bottle, and well shaken every day for at least a fortnight.

A very good instantaneous ink, if we may so call it, may be made by mixing a little pyrogallic acid and powdered green copperas (about equal parts) with a small quantity of white sugar, and dissolving in water. A little solution of gum may be added with advantage. Ink may thus be made in a few moments, which flows most freely from the pen, giving traces of a rich blue-black. When troubled at one time by the shortcomings of his ordinary writing fluid during the "'witching hour o' night," the author solaced himself by improvizing an ink as above, the materials for which his laboratory fortunately supplied him

An important improvement in the manufacture of black inks consists in *roasting the gall-nuts* before using them, whereby a portion of the gallic acid contained in the nuts becomes converted into *pyrogallic acid* (p. 158), a sub-

stance very soluble in water, and which, coming in contact with a solution of sulphate of iron, forms an intense blue-black ink which flows well from the pen, and writes black at once. In roasting the galls, great care must be observed that the heat employed is not sufficient to volatilize the pyrogallic acid formed, otherwise there will occur a waste of the principal effective agent, and a consequent loss in the ultimate product

Copying ink may be made by adding to good black ink, sugar-candy, treacle, lump or moist sugar. The following proportion will be found useful: (1) Sugar-candy or lump sugar, 1 ounce; rich black ink, $1\frac{1}{2}$ pint. (2) Treacle or moist sugar, $1\frac{1}{2}$ ounce, black ink, $1\frac{1}{2}$ pint. In each case the saccharine substance must be well dissolved in the ink

Horticultural or **gardener's ink.**—Take chloride of platinum 2 drachms, distilled water 1 pint. Dissolve and keep in a stoppered glass bottle. When required for use, apply with a clean quill pen to labels made of sheet zinc. The writing turns black almost immediately, and it cannot be effaced by washing, consequently it is very useful for garden or greenhouse labels, which have to be subjected to frequent irrigation or natural moisture

Indelible ink.—To good black ink 1 pint, add gradually $\frac{1}{4}$ ounce of lamp-black, previously heated to dull redness in a covered crucible. This ink resists the action of weak acids, chlorine, and dilute alkalies.

Incorrodible ink.—Lamp-black and Prussian blue, in the proportions to make a deep black colour, are to be ground with boiled linseed oil, to which a little turpentine may be added to render it more limpid. Or asphaltum may be dissolved in amber varnish, with addition of oil of turpentine. To this lamp-black is to be added.

Indian or **China ink.**—Lamp-black ground into a thick paste with a weak solution of potash. The paste is afterwards to be diffused through water rendered slightly alkaline by potash. Pass through a filter, wash repeatedly, and dry. Afterwards again work the dried mass into a paste by means of a strong decoction of carrageen, or Irish moss, to which a few drops of essence of musk and essence of ambergris may be added. The pasty mass is finally moulded into cakes, which when dry and hard are embellished with Chinese characters and figures. There are numerous other processes for making Indian ink, but that given above may be considered one of the best. The Chinese, in making their ink, employ as a medium an infusion or decoction of certain seeds which yield a glutinous transparent mucilage which imparts great brilliancy to the colour

Blue inks.—Under the title of " Writing Fluids " many. important and elegant preparations have from time to time been introduced, some of the most interesting of which are given below.

1. Soluble Prussian blue is dissolved in distilled water until the required depth of colour is obtained. This forms a very beautiful blue ink, but is readily affected by alkalies, as potash or soda.

2. Prussian blue, 6 parts; oxalic acid, 1 part. Triturate with a small quantity of water into a smooth paste; finally dissolve in sufficient water to make a fluid ink.

3. The Rev. J. B Reade took out a patent many years ago for an ingenious combination which was designed to render the ink proof against the action of either acids or alkalies. Its composition is a mixture of good black ink and soluble Prussian blue. " It cannot be erased from

paper," says the patentee, "by any common method of fraudulent obliteration without the destruction of the paper." This ink writes a greenish-blue colour, which eventually turns an intense black.

Coloured inks.—Very pretty inks may be obtained by employing strong decoctions of any of the materials used in dyeing, with the addition of alum or other appropriate mordant, and a little gum. At the present time purple and other "fancy inks," if we may so .call them, are made from solutions of aniline colours, a fact which the user will readily recognise when he observes the characteristic bronze appearance of the dried ink upon the cork of the bottle.

Green ink may be readily made by dissolving verdigris in cream of tartar or strong vinegar.

Gold ink.—When gold-leaf is ground with honey upon a marble slab by the aid of a muller, the metal soon becomes reduced to an impalpable powder, and it may be easily separated from the honey by dissolving the latter in hot water. The metal, from its superior gravity, soon falls to the bottom of the vessel, in the form of *gold bronze*. A small quantity of this impalpable gold powder mixed with gum-water forms a very brilliant gold ink, useful for "illuminating" and other ornamental purposes. When the ink has become dry, it may be rendered even more brilliant by burnishing, a wolf's tooth being recommended for the purpose.

Marking ink.—This ink, as is well known, is intended to produce indelible stains or markings upon linen and other fabrics. Some of the marking inks which appeared first in the field required the surface of the linen to be written upon to be first brushed over with a "preparation," as it

was called, and when this was dry, the indelible ink was applied. A marking ink requiring "no preparation" next made its appearance, and this at once met with universal adoption. This ink may be made as follows: Dissolve $\frac{1}{4}$ ounce of nitrate of silver in $\frac{3}{4}$ ounce of distilled water. Add strong liquid ammonia gradually until the precipitate which is at first formed becomes redissolved, then add strong solution of gum $1\frac{1}{2}$ drachm, and colour slightly with either syrup of buckthorn, sap green, or indigo, reduced to powder. When a hot iron is passed over the surface written upon, it at once turns black, and the mucilage (solution of gum) prevents the ink from spreading beyond the surface traced by the pen.

Printing or **printer's ink.**—The preparation of this important ink may be divided into two parts—first, the preparation of a kind of varnish; and second, the composition of the ink. *The varnish* is made by boiling linseed or nut oil in an iron vessel capable of holding at least double the quantity. When it begins to boil the oil is kept well stirred with a ladle, and if it does not ignite spontaneously, when smoke arises, the workman sets it on fire by means of a lighted piece of paper. The pot is soon after removed from the fire, and the oil allowed to burn until a sample taken from the pot and cooled upon a palette-knife becomes *stringy*, as it is called. A cover is then placed over the vessel to extinguish the flame of the burning oil. When the froth occasioned by the boiling has subsided, black resin is added in the proportion of $\frac{3}{4}$ lb. to 1 lb. for each quart of the boiled oil. The mixture is then well stirred until all the resin is dissolved; $1\frac{3}{4}$ lb. of brown soap, cut into slices, is next added gradually, and the stirring continued until the whole ingredients are

thoroughly united. To assist the perfect incorporation of the materials the pot is again placed on the fire. The vessel containing the "varnish" is then covered and set aside.

The ink may be made from powdered Prussian blue and indigo, each 2½ ounces; mineral lamp-black, 4 lbs.; vegetable lamp-black, 3½ lbs. These are to be gradually stirred into the varnish while still warm, and the whole composition must then either be worked up by means of a muller and slab, or passed through a grinding-mill.

Coloured printing inks are made by adding to the above varnish, vermilion, carmine, yellow chromes, red-lead, ultramarine, cobalt blue, Scheele's green, burned ochre, yellow ochre, sepia, and in fact any of the colours used in ordinary painting.

Red ink.—Brazil wood, ground, 4 ounces, white-wine vinegar, hot, 1½ pint. Place in a glass or enamelled vessel and digest for a day or so; then simmer gently for half an hour; finally add alum and gum-arabic, of each, ½ ounce.

Or take of ground Brazil wood 10 ounces, white vinegar 10 pints. Put the mixture aside for a few days, then simmer gently as before until about half the liquor remains, finally add Roche alum, 4½ ounces. When these are dissolved the ink should be bottled, when it is ready for use.

Sympathetic inks, as they are called, are fluids which leave an invisible impression upon paper when used for writing, but which may be rendered visible either by warming the paper, or by applying some other chemical substance to bring out or develop the writing. One of the most striking and beautiful of the sympathetic inks may be readily made by dissolving a few grains of *chloride*

of cobalt in water. The solution has a faint pinkish tint which is scarcely visible on paper while moist, and which disappears almost entirely when dry. When the paper which has been written upon by this solution is held before the fire for an instant, the writing appears of a pale-blue colour, which vanishes when the paper has again become cold. The writing may thus be alternately caused to appear or become invisible at will. Onion juice writes colourless, but when heated the tracings appear yellow. Equal parts of sulphate of copper and sal-ammoniac dissolved in water also furnish a colourless ink which becomes yellow on the application of heat. A dilute solution of galls or pyrogallic acid form an invisible ink which will turn black when a weak solution of sulphate of iron is poured over the paper. A weak solution of yellow prussiate of potash turns blue when a dilute solution of sulphate of iron is brushed over the invisible writing produced by the yellow prussiate. A weak solution of nitrate of silver turns brown when exposed to sunlight, and a solution of chloride of gold under similar conditions yields a purple colour.

The invisible or sympathetic inks have also been called *diplomatic inks*, from their having been occasionally used for secret correspondence.

PYROGALLIC ACID.

This acid, so much employed in photography, is readily obtained by heating in a retort, by means of an oil bath, either gallic acid or tannic acid. It is important that the temperature of the oil bath should not exceed 420° Fahr. When the proper temperature is attained, crystals of pyro-

gallic acid become deposited in the receiver (which must be kept cool), and so long as they continue to do so the heating process is kept up.

Pyrogallic acid when pure appears in the form of white crystals of exceeding lightness. It is very soluble in water (unlike gallic acid, which is sparingly so). Besides its extensive employment as a developing agent in photography, a solution of the *crude acid*, mixed with a little spirit, is used as a dye for the hair, to which it imparts a brown colour; since, however, it operates in the same way upon the skin, its employment in inexperienced hands might not be unattended by unpleasant consequences, especially if a drop or two happened to fall upon the tip of the patient's most prominent feature!

FUSIBLE ALLOYS.

		PARTS.
1.	Bismuth	8
	Lead	4
	Tin	4
2.	Bismuth	2
	Lead	5
	Tin	3
3.	Bismuth	8
	Lead	5
	Tin	3
4.	Bismuth	8
	Tin	4
	Lead	5
	Antimony	1

							PARTS.
5. Bismuth	.	.	.		.	.	8
Tin	.	.	.	.	.	.	2
Lead	.	.	.	.	.	.	4
Cadmium		.	.		.	.	2
6. Lead	.	.	.	.	.	.	3
Tin		.	.	.	.	.	2
Bismuth .	.	.	.	.	.	.	5
7. Bismuth .	.	.	.	.	.	.	5
Lead		.	.	.	.	.	3
Tin	.		.	.	.	.	2
Quicksilver	.	.		.	.	.	1

Of the above formulæ No. 5 melts at the lowest temperature, namely, at 160° Fahr., or 52° below the boiling-point of water (212° Fahr).

BLEACHING.

The whitening, or bleaching, of textile fabrics, or the filaments and fibres from which they are made, as wool, silk, cotton, flax, etc., is closely connected with the arts of dyeing (see p. 164) and calico-printing, inasmuch as the latter process cannot be properly effected until the various fabrics have been purified and whitened.

Exposure to the air and sunshine is the oldest system known for bleaching yarn and cloth, and though ·not so rapid as the chemical methods generally adopted at the present day, has doubtless the advantage of being less injurious to the fibres from which textile fabrics are made.

The art of bleaching is believed to have been practised both by the Assyrians and Egyptians at a very remote

period; and the frequent references in Scripture to "*white linen*," "fine linen, *white* and clean," and "white raiment," lead to the belief that even in Abraham's time linen was subjected to some kind of bleaching process ere it was destined to be worn by persons of distinction or of superior position. Herodotus speaks of the Babylonians wearing "*white* cloaks." It is probable that the *blanching*, or bleaching, action of the air and sunshine were taken advantage of by the ancients, and that this natural system of whitening linen was commonly practised by them, as indeed it is in our own day, to some extent. The alternate washing and drying in the sun is well known to whiten unbleached textile fabrics, more especially if the material be previously steeped in alkaline solutions, milk of lime, ammoniacal liquor, etc.

Doubtless soap of some kind, with fuller's earth, potter's clay, marl, and other mineral substances of a like nature, were employed by the ancients for whitening woollen cloths.

At the present day bleaching is chiefly effected by chemical means, the active agent being *chlorine* obtained from a weak solution of chloride of lime. The various processes through which cotton fabrics have to pass in the operation of bleaching may be thus briefly explained: The "pieces," which are about 30 yards long, are tacked together endwise, forming a continuous length of from 300 to 350 yards. The pieces are afterwards *singed*, or *sheared;* they are then *crushed* into a *rope-like* form by being drawn through an aperture with a porcelain or glass surface. The pieces are then "bucked," or boiled, in milk of lime (made by mixing about 1 lb. of slaked quicklime in 2 gallons of water) for about twelve hours, after which they are rinsed in a washing-machine.

The next operation is called "souring," that is, placing the pieces in a dilute solution of hydrochloric acid, after which they are again washed in a machine similar to that employed in the above operation. The "bucking," or boiling, is now repeated, and continued for about fifteen or sixteen hours, in a solution composed of soda-ash 17 lbs., resin 3 lbs., and water 50 gallons. After this operation the pieces are again washed.

The pieces, or "goods," are next placed in a slate or wooden cistern, when they are "chemicked," as it is termed, that is, submitted to the action of a weak solution of chloride of lime. After this the cloth is again washed, and once more "bucked" for a few hours in a weak solution of soda (made by dissolving soda crystals 1 lb. in 5 gallons of water for every 35 lbs. of cloth). After this operation the goods are again "chemicked," and washed as before.

The process of "souring" in dilute hydrochloric acid is next repeated, and the pieces are then placed on low stools, or "stillages," for several hours, after which they are thoroughly washed to remove all trace of acid. Finally, the goods are pressed between rollers, then dried between metal cylinders heated by steam, and are then "dressed," or stiffened, by means of starch, etc., and afterwards "finished" for sale.

In bleaching *silk* it is usual first to steep it in a solution of white curd soap, and afterwards boil it in the same solution. It is next rinsed repeatedly, a little indigo blue being added to the last rinsing water to give the silk an opalescent or pearly appearance.

When silk is required to be absolutely white, that is, without tint, the goods, or articles made from it, are

submitted to the action of sulphur fumes for several hours, after which they are repeatedly rinsed in water. The white silk of China requires neither "sulphuring" nor boiling. In the process of bleaching, "raw" silk loses in weight from 4 to 5 ounces per lb.

Wool, before it can be bleached, is subjected to processes which have the effect of removing certain matters, or "yolk," which would retard the action of the bleaching agent—the fumes of sulphur. The wool is first steeped in warm water, after which it is placed in baskets to drain. It is then well rinsed, again drained, and then hung up to dry. If the wool is required to be whitened in the fleece, or in the yarn, it is spread out, or hung up, while in a moist condition, and then submitted to the sulphuring process, after which it is rinsed in water, then dried or pressed, or placed in a weak solution of soft soap, and afterwards well rinsed and dried.

Woollen fabrics, independent of the "yolk," or greasiness which naturally attaches to the wool itself, require to be relieved from the oil, dirt and "dressing" resulting from the process of weaving. This is done in the "fulling-mill," where the woollen stuffs are treated with soap and *fuller's earth,* after which they are well washed and scoured, when they become ready for the dyeing process.

The process of "sulphuring" is generally conducted thus: The woollen goods are suspended by pegs, or the fleece wool spread about the upper part of a room, in the interior of which several cast-iron vessels are placed containing sulphur, which is afterwards ignited. The lower door of the room or chamber is then carefully luted with clay, and by the following day the bleaching

process is complete. The goods are then removed and
well washed.

Straw and straw-plait, as also the articles made from
them, are first steeped in a solution of caustic soda, and
afterwards submitted to the action of sulphur fumes. In
bleaching articles of this kind on a small scale, it is only
necessary to place them in a closely-fitting box, at the
bottom of which a shallow iron tray resting on sand or
garden mould may be placed. A few red-hot cinders
being put into the tray and a small piece of brimstone
laid upon them, the box is then carefully closed, and left
for a few hours, when the bleaching effects of the sulphur
will become apparent. It is hardly necessary to say that
inhaling the fumes of sulphur should be avoided, as they
are exceedingly irritating to the lungs.

Bleaching with chlorine, or a solution of chloride of
lime, is extensively adopted for whitening the material
used in paper-making. In France chlorine gas is passed
direct from the generators in which the gas is liberated
into the cisterns containing the pulp. In England
a solution of chloride of lime is used for bleaching
paper-pulp, but this requires very careful and complete
washing to remove all trace of the bleaching liquor, other-
wise the fibre acquires a brownish tint when dry, and
apt to become rotten in course of time.

DYEING.

The art of dyeing was clearly known at a very early
period of the world's history, as also was the kindred art
of calico-printing. According to Pliny, the Egyptians
practised the latter art at a very remote epoch, and indeed

it is evident that they were acquainted with some chemical knowledge of the subject, as will be seen from the following extract from Pliny's writings:—

"Robes and white veils are painted in Egypt in a wonderful way. They are first imbued, not with dyes, but with dye-absorbing drugs, by which, though they be unaltered, yet, when immersed for a little while in a caldron of the boiling dye-liquor, they are found to become painted. Yet, as there is only one colour in the caldron, it is marvellous to see many colours imparted to the robe in consequence of the influence of the excipient drug. Nor can the dye be washed out. A caldron, which would of itself merely confuse the colours of cloths previously dyed, is thus made to impart several pigments from a single dyestuff, *painting as it boils*."

In the Bible Moses speaks of raiment being dyed blue and purple and scarlet, and of sheepskin being dyed red. Plutarch in his "Life of Alexander" says that the Greeks found in the treasury of the King of Persia "a large quantity of purple cloth which was as beautiful as at first, though it was 190 years old. The ancient Romans must also have been acquainted with the art of dyeing, for in the games of the circus the respective performers were distinguished by various colours, as green, orange, grey, and white. In India the art of calico-printing must have been known at a very early date, and indeed it appears to have been practised with extraordinary success.

Although it is probable that many of the processes employed by the ancients in dyeing and calico-printing have been lost to us, owing to the secrecy which invariably enveloped discovery in those early times, the researches of modern experimentalists have furnished us with an endless

variety of processes amply sufficient to meet the requirments of the world in our own days. Many substances unknown to the ancients have from time to time been added to our list of dye-stuffs, as cochineal, Brazil wood, annatto, quercitron, logwood, etc., and more recently the invaluable aniline dyes. Indigo, which the Romans knew only as a pigment, is in our time employed as one of the most important dyeing materials. In the reign of Queen Elizabeth, however, this very harmless vegetable substance was reputed to be "a dangerous drug," and Parliament in its blind stupidity and ignorance passed an Act forbidding its employment! Searchers were engaged to burn both indigo and logwood in every dyehouse in which they were to be found. In Charles II.'s reign this barbarous Act was repealed.

Dyeing is applied to fabrics of cotton, hemp, and flax; also to silk and wool; the latter, being animal substances, requiring different treatment to those of vegetable origin. The stuffs to be dyed are first prepared by removing from them any foreign matters which may adhere to them naturally, or may have been imparted to them in the process of weaving, as soapy matters, "dressing paste," dirt from weavers' hands, etc. The process of bleaching (p. 160), to which the reader is referred, embodies the cleansing and purifying of the various fibres and filamentary substances, and the fabrics manufactured from them, and it is therefore unnecessary to repeat it in the present sketch.

The dye-drugs, as they are called, are certain colouring matters which, either separately or combined with each other, are formed into decoctions or infusions, with the addition of other materials to vary or modify the required tints or shades of colour.

Indigo dye for cotton and linen goods generally consists of a bath prepared with water, indigo, sulphate of iron, lime, and sometimes carbonate of soda. When traces of oxide of iron are found to rest upon cloth dyed in a vat thus composed, it is usual to remove it by steeping the cloth in dilute acid.

In dyeing silk and wool with indigo, the bath or vat is composed of indigo, potash, madder and bran, the latter substances answering the same purpose as the sulphate of iron in the former vat. To secure uniformity in dyeing silk and wool in this vat, the utmost care has to be observed, the addition of indigo and alkali being made very cautiously. Sulphate of indigo is also used in dyeing silk and wool, but although it yields a very good colour, it is not considered so permanent in its character as the dye from good commercial indigo, as above prepared.

Logwood, with the addition of verdigris, acetate of alumina, and acetate of copper, yields a blue or violet colour upon wool or cotton; nut-galls and copperas produce a blue-black shade; logwood, galls, and copperas, by well boiling and afterwards exposing to the air, also yield a black. Prussian blue, with perchloride of iron or tin, yields a rich dark blue. Some of the most delicate blue tints, possessing great beauty and brilliancy, are obtained from aniline, or coal-tar dyes (p 3).

Cochineal, madder, safflower, lac-dye, logwood, etc., are employed (with chloride of tin as a mordant) in producing red dyes.

Purple dyes are generally obtained at the present day from aniline colours, whereas formerly cudbear or archil were employed.

The beautiful violet colour known as "mauve" is produced by an aniline or coal-tar colour.

For producing yellow dyes, *quercitron*, turmeric, fustic, annatto, and French berries are employed.

Mordanting, as it is termed, is the process of fixing the colours employed in dyeing. The effect which a mordant (as acetate of alumina, perchloride of tin, perchloride of iron, for example) produces is to precipitate and render insoluble, within the delicate pores of vegetable fibres, the colouring matter of the varied dye-stuffs employed. An admirable exposition of the principle upon which mordants act upon fabrics and dye-stuffs is thus given by Ure:—

"Experience has proved that of all the bases, those which succeed best as mordants are alumina, tin, and oxide of iron; the first two of which, being naturally white, are the only ones which can be employed for preserving to the colour its original tint, at least without much variation. But whenever the mordant is itself coloured, it will cause the dye to take a compound colour quite different from its own. If, as is usually said, the mordant enters into a real chemical union with the stuff to be dyed, the application of the mordant should obviously be made in such circumstances as are known to be most favourable to the combination taking place; and this is the principle of every day's practice in the dyehouse.

"In order that a combination may result between two bodies, they must not only be in contact, but they must be reduced to their ultimate molecules. The mordants that are to be united with stuffs are, as we have seen, insoluble of themselves, for which reason their particles must be divided by solution in an appropriate vehicle. Now this solvent or menstruum will exert in its own favour an

affinity for the mordant, which will prove to that extent an obstacle to its attraction for the stuff Hence we must select such solvents as have a weaker affinity for the mordants than the mordants have for the stuffs. Of all the acids which can be employed to dissolve alumina, for example, vinegar is the one which will retain it with least energy, for which reason the acetate of alumina is now generally substituted for alum, because the acetic acid gives up the alumina with such readiness that mere elevation of temperature is sufficient to effect the separation of these two substances. Before this substitution of the acetate, alum alone was employed; but without knowing the true reason, all the French dyers preferred the alum of Rome, simply regarding it to be the purest. It is only within these few years that they have understood the real grounds of this preference.

"The two principal conditions, namely, extreme tenuity of particles and liberty of action, being found in a mordant, its operation is certain. But as the combination to be effected is merely the result of a play of affinity between the solvent and the stuff to be dyed, a sort of partition must take place, proportioned to the mass of the solvent, as well as the attractive force. Hence the stuff will retain more of the mordant when its solution is more concentrated, that is, when the base diffused through it is not so much protected by a large mass of menstruum, a fact applied to very valuable uses by the practical man. On impregnating in calico-printing, for example, different spots of the same web with the same mordant in different degrees of concentration, there is obtained in the dye-bath a depth of colour upon these spots intense in proportion to the strength of their various mordants. Thus, with a solution

of acetate of alumina in different grades of density, and with madder, every shade can be produced, from the fullest red to the lightest pink; and with acetate of iron and madder, every shade from black to pale violet."

After the fabric has been subjected to the "mordanting" process it is hung up in a room, and submitted to the continued action of steam and air, which have the effect of accelerating the union of the mordant with the fibre. The term "aging" is applied to this part of the operation.

Dunging, or cleansing, is an important process connected with dyeing, since by its aid all loose and objectionable matters are removed from the cloth which would interfere with the operation of dyeing. A bath of cow-dung diffused through hot water is prepared, in which the cotton goods are immersed. Dunging is applied to remove the uncombined mordant from the cloth, the thickening matters (gum and starch) employed in weaving, etc.

Dyeing is effected in cold or hot baths, but more generally the latter, which not only hastens the operation, but also favours uniformity of result. When a cold bath is employed, the goods require to be well stirred in the bath after first immersion, then removed, wrung or pressed, and again dipped, these operations being repeated several times in order to ensure a uniform moistening of the fabric.

In dyeing with aniline colours, the dry crystals are first dissolved in methylated spirit, or spirit of wine, and small quantities of the powerful tincture thus formed added to warm water. A momentary immersion of silk or woollen articles in this bath will impart a brilliant colour of any required shade, the depth of which may be increased by a longer immersion, with the addition, from time to time, of a further supply of the liquid colour.

MANUFACTURE OF BLACKING.

It is believed that blacking, or some kind of leather polish, was known to the ancients, but it was not until the reign of Charles II. that a compound of this nature was introduced into England from France   The general adoption of a polish for boots and shoes in this country only dates, however, from about the middle of the last century.

It is a remarkable fact that England not only produces the best quality of shoe-blacking, but also by far the greatest quantity, of any country in the world.

The principal ingredients in the manufacture of blacking are bone-black, treacle, oil of vitriol, sperm oil, gum-arabic and vinegar, or sour beer. In mixing these substances the following system is adopted: The bone-black is put into a stoneware or wooden vessel, the sperm oil is then added, and these are well triturated or rubbed together; the treacle is next added gradually, and the mass is then well ground or worked up until the oil is perfectly "killed," as it is termed.   It is very important at this stage of the operation to ensure a *perfect* admixture   The oil of vitriol is afterwards diluted with about three times its bulk of water, and this is cautiously and gradually added to the above with constant and brisk stirring. The mass after a while is of a uniform pasty consistence, when it must be allowed to repose for several days, being well covered during that time.

The gum is next to be dissolved in the vinegar or sour beer, and this solution gradually added to the above, and the whole well stirred once or twice daily for three or four days.   If necessary, a further addition of vinegar

may be added; and it is considered an advantage if all the ingredients, excepting the vitriol, are heated before mixing.

Having thus briefly shown the rationale of the process of mixing the materials used in blacking-making, the following formulæ will exhibit the proportions in which they are generally compounded:—

1. **Liquid blacking.**—Bone-black (or ivory-black, as it is commonly called), 16 parts; treacle, 12 parts; oil of vitriol, 3 parts; sperm oil, 2 parts; gum-arabic, 1 part; vinegar or sour beer, 48 to 50 parts.

2. Ivory-black, 16; treacle, 8; oil of vitriol, 4; water, 2; sperm oil, 2 parts; gum, 1 part; soft water instead of vinegar, 64 parts.

3. Finely powdered ivory-black, 2 lbs.; sperm oil, $\frac{1}{4}$ pint. Mix well and then add gum-arabic dissolved in $\frac{1}{2}$ pint of strong vinegar. Incorporate these well together. About twenty-four hours after, add of vinegar or sour beer 3 to 4 pints. Stir well at least once a day for a week

4. **Indiarubber blacking.**—Indiarubber in small pieces, 18 ounces; rape oil (hot), 1 gallon: dissolve. Add to this solution powdered ivory-black, 60 lbs.; treacle, 45 lbs.; and mix well. Next add gum-arabic, 1 lb., dissolved in 20 gallons of vinegar. These ingredients are incorporated in a paint-mill, after which 12 lbs. of sulphuric acid are added and the whole well stirred together, and this is repeated daily for about fourteen days. 3 lbs. of gum-arabic are next added, and well mixed in, and the combined mass is stirred for about half an hour each day for fourteen days longer, after which the liquid blacking will be ready for bottling. Liquid blacking may be made without oil of vitriol by employing vinegar or sour beer in its place.

5. **Paste blacking,** which is so extensively used now-adays, is made by simply omitting the vinegar, sour beer, and water employed in the manufacture of liquid blacking.

Cooley makes the following remarks upon the subject of blacking in his Cyclopædia: "To produce a *first-rate article of blacking* it is absolutely necessary that the ingredients be of the best quality, and used in the proper proportions; and that the order of their admixture and the general manipulation be conducted, under ordinary circumstances, in the manner described. The proportions of the *treacle* and the *oil* (the most expensive of the ingredients) should not be stinted, and indeed that of the latter may be safely increased in quantity without materially affecting the polish, and with manifest advantage as far as the softness and durability of the leather to which it is applied is concerned. The manipulations required in the manufacture of both *paste blacking* and *liquid blacking* are essentially the same; the difference between the two articles, when the same materials are used, depending entirely on the quantity of liquid added. Thus, as noticed before, by diluting *paste blacking* with *water, vinegar,* or *beer-bottoms,* it may be converted into *liquid blacking* of a nearly similar quality; and, by using less fluid matter, the ingredients of liquid blacking will produce *paste blacking.* One thing must, however, be observed, and that is that the ivory-black used for *liquid blacking* should be reduced to a much finer powder than for *paste blacking;* as, if this is not attended to, it is apt to settle at the bottom, and to be with difficulty again diffused through the liquid. Persons who object to the use of blacking containing oil of vitriol may employ formula 3. The vitriol, however, greatly contributes to promote the

shining properties of the blacking, and in small quantities, or in the proper proportion, is not so injurious to the leather as some persons have represented, as it wholly unites itself to the lime of the *bone-phosphate* contained in the ivory-black, and is thus neutralized, insoluble *sulphate of lime* and an *acid phosphate* or *superphosphate* being formed. It is the *latter* that gives the acidity to a well-made sample of blacking, and not the sulphuric acid originally added to it. In this way the larger portion of the ivory-black is reduced to a state of extremely minute division, and with the other ingredients forms a strongly adhesive paste, which clings to the surface of the leather, and is susceptible of receiving a high polish by friction when in a scarcely dry state This is the reason why *lamp-black* should *never* be employed for blacking to the exclusion of the necessary proportion of *bone-black*, as it has no earthy base to absorb or neutralize the acid, which if left in a free state would prove very hurtful to the leather. Oil of vitriol is now employed in the manufacture of all the more celebrated and expensive blackings, and that simply because no other substance is known so efficient and so little injurious to the leather. In the common blackings of Germany *hydrochloric acid* is often used to the entire exclusion of oil of vitriol, but blacking so prepared possesses several disadvantages from which that of England is free.

"We may here farther remark that the blackings of different houses vary considerably in some of their properties, as also do those of even the same maker, by age. Some blackings dry off rapidly, and give a very brilliant polish with very little labour; whilst others take a little longer to dry off, and somewhat more labour to polish

them. The *former* are best adapted to hasty use, and when a very brilliant surface is desired; the *latter* when depth of polish, without extreme brilliancy, satisfies the wearer. The *first* best meets the requirements of fashionable life; the *last* those of the middle classes and pedestrians exposed to dirt, mud, and the various vicissitudes of travelling and weather. To the *one* belong the blackings of Everett, Day & Martin, etc.; to the *other* those of Warren, Bryant & James, and most of the smaller manufacturers, with nearly all the paste blacking of the more respectable shops. Time, however, equalizes the qualities of these two classes. Blackings which are crude, moist, and oily, lose these properties, and become drier and more brilliant by age. The practice of several of the West-end boot and shoe makers is never to use a blacking which they have not had in stock at least a twelvemonth."

6. **Harness blacking** is composed of glue, 4 ounces; gum-arabic, 3 ounces; dissolved in 3 pints of hot water, to which 6 ounces of treacle and 5 ounces of finely-powdered ivory-black are added. These ingredients are to be well worked up by trituration over a slow fire, and as the mixture becomes thickened by evaporation, small samples are taken from time to time and set aside to cool; when of the proper consistence it is placed in bottles for use. It should be kept well covered.

Water-proof harness blacking may be made by melting together bee's-wax, 6 ounces; mutton suet, 2 ounces; to which add finely-powdered sugar-candy, 6 ounces; soft soap, 2 ounces; lamp-black, $2\frac{1}{2}$ ounces; finely-powdered indigo, $\frac{1}{2}$ ounce. Mix these ingredients *well* together, keeping the wax and suet in a melted state

by gentle heat. Lastly add oil of turpentine, $\frac{1}{4}$ pint. The compound should be poured into tins or gallipots.

Another good recipe for harness blacking is composed of bee's-wax, 1 lb.; soft soap, 6 ounces; ivory-black, $\frac{1}{4}$ lb.; powdered Prussian blue, 1 ounce. These ingredients must be well ground together, after which add linseed oil, 2 ounces; oil of turpentine, $\frac{1}{2}$ pint.

VARNISH-MAKING.

In the preparation of spirit varnishes an ordinary still is used, and this is heated either by steam or boiling water. The resinous matters and alcohol are introduced into the still, in the head of which a stuffing-box is placed through which a stirring-rod passes to the bottom of the still. When the alcohol distils over, the heat is lowered a little, and the distilled spirit returned to the still (except when an excess is employed) in order to keep the varnish at a uniform strength. When the resinous matter has become thoroughly dissolved, the still is allowed to cool, after which the head is removed. The varnish is then passed through a fine silk sieve, the clear solution being then placed aside in well-covered vessels to clear.

Carriage varnish.—Gum sandarach, $\frac{1}{4}$ lb.; pale shellac, $\frac{3}{4}$ lb.; pale resin, $\frac{1}{2}$ lb.; alcohol, 3 quarts. Dissolve, and add Canada balsam, $1\frac{1}{2}$ lb. Dries very quickly.

Gilder's varnish.—Pale-green lac, dragon's blood, gamboge, and annatto, of each $12\frac{1}{2}$ ounces; saffron, $3\frac{1}{4}$ ounces. Dissolve each resin separately in 5 pints of alcohol. The dragon's blood and annatto must be made into tinctures with a like quantity of alcohol, and portions of these are added to the varnish to give the required golden tint.

Varnish for gun-barrels.—Shellac, 1½ ounce; dragon's blood, 3 drachms; rectified spirit of wine, 1 quart. This varnish is applied to gun-barrels after the process of "browning" has been accomplished.

Japan varnish.—Copal or pale amber varnish is thus designated, and is used for japanning tin, papier maché, etc.

Lac varnish.—Pale seed lac or shellac, 4 ounces; alcohol, 1 pint. Pyroxilic spirit, or wood naphtha, may be substituted for the alcohol.

Lacquer, or coloured lac varnish, is made by adding to rectified spirit, 1 quart; ground turmeric, 2 ounces. After maceration for a week or so press the tincture through a cloth, and add gamboge, 3 drachms.

White hard varnish.—Gum sandarach, 5 lbs.; camphor, 2 ounces; powdered glass, 3 lbs; rectified spirit, 7 quarts. Treat as for mastic varnish; strain, and add 1 quart of pure Canada balsam.

Brown hard spirit varnish.—Gum sandarach, 3 lbs.; pale shellac, 2 lbs; alcohol, 2 gallons After dissolving completely, add 1 quart of turpentine varnish. Agitate well, and set aside for several weeks, when the clear varnish may be decanted

Picture varnish.—Pale mastic, 5 lbs.; coarsely powdered glass, 3 lbs., rectified oil of turpentine (lukewarm), 2 gallons. Place these ingredients in a bottle securely corked, and agitate well for several hours. When the gum is thoroughly dissolved, the solution should be strained through a cloth and allowed to repose for some days.

Patent-leather varnish.—Boiled linseed oil, or "drying oil," is the basis of this varnish, and with the

addition of pale Prussian blue and a little vegetable black, forms the varnish of the *first coat* applied to the prepared skins.   After the skins have been stretched on a board, they are cleansed from any greasy matter which may attach to them by means of fuller's earth moistened with water.   When dry, this first coat is polished with finely pounded pumice.   A *second coating* is then laid on, in which *pure* Prussian blue is used instead of the pale blue, which contains alumina.   The *third coating* consists of the same materials, with the exception that the linseed oil is boiled until it becomes "stringy" with an additional quantity of pure Prussian blue and vegetable black.   The final coating is like the third, but contains in addition $\frac{1}{2}$ lb. of pure dark-coloured Prussian blue and $\frac{1}{4}$ lb. of vegetable black to each gallon of varnish.   Sometimes a little amber varnish or oil copal is added.   After each coating is applied the leather is placed in a stove and heated to about 120° Fahr., and is then polished with fine pumice as before.

ARTIFICIAL PARCHMENT.

The remarkable change which cotton fibre undergoes when brought in contact with concentrated acids (see Gun-cotton, p. 24) has been taken advantage of in the treatment of paper, by which it is made to resemble animal parchment in a remarkable degree.   In the preparation of artificial parchment, unsized paper is immersed for half a minute in very strong sulphuric acid, after which it is plunged in a very weak solution of ammonia in water.

By another process—and one which is extensively adopted by Delarue & Company—the paper (unsized) is plunged for a few seconds in a mixture composed of

sulphuric acid diluted with from half to a quarter of its bulk with water.

This interesting chemically-prepared parchment is extensively used for labels, for covering pickle-jars, jam-pots, and preserves, and for many other useful purposes.

ESSENTIAL OILS.

These delicate volatile products of the vegetable kingdom, to which we are indebted for the delightful fragrance of our flowers, our spices and aromatic herbs, and the varied perfumes so grateful to our senses at those periods of the year when Nature's perfumery store is "closed for the season," are obtained from various parts of plants and trees These "volatile oils," as they are scientifically termed, exist in the flowers, leaves, seeds, fruit, bark, roots, and wood of nearly all the members of the great vegetable family. The term "essence" is frequently applied to alcoholic solutions, or tinctures, of the essential oils, as "essence of bergamot," "essence of roses," etc.

Essential oils are generally obtained by *distillation*, the fragrant substance being placed in a still with about an equal weight of water, and the heat applied by means of a steam or water bath, by preference. Sometimes common salt is added to the water-bath, to enable the water to attain a higher temperature than the ordinary boiling-point (212° Fahr.). The vapours which pass over consist of water impregnated with essential oil, which after settling for some time rises to the surface, except in those cases where the oil is heavier than water.

Some essential oils, as those of lemons and oranges, are obtained by pressure, the rinds of the respective fruits being

placed in a powerful press, and the oil collected as it flows from the expressed fruit. The "London Pharmacopœia" directs that "the *fruit* of anise, caraway, and juniper; the *flowers* of camomile, lavender, and elder; the *berries* of allspice; the *tops* of rosemary; and the *entire* recent plants of other herbs are to be employed" "Put any one of these into an alembic, then pour in as much water as will cover it, and distil the *oil* into a large vessel, kept cool."

In the distillation of essential oils Chevallier gives the following rules: "Operate upon as large quantities as possible; conduct the distillation *rapidly;* divide the substances minutely, to facilitate the extrication of the oil; employ only sufficient water to prevent the matter operated upon from *burning,* and from thus becoming empyreuma, employ, when possible, water which has already been distilled from off the same substances, and has thus become saturated with oil."

Essential oils may be rectified by redistillation, without water, at a low temperature. Only about one-half of the oil is allowed to pass over, the remaining portion being usually mixed with raw oil to be sold at a lower price.

ETHER, OR SULPHURIC ETHER.

This extremely volatile fluid is formed by mixing sulphuric acid and alcohol in certain proportions with subsequent distillation of the product. To make ether on a small scale, put 2 lbs. of rectified spirit of wine in a glass retort placed on a sand-bath, then pour on 2 lbs. of sulphuric acid. Heat is now to be applied so that the liquor may boil as quickly as possible. The ether which forms is

collected in a well-cooled receiver. Continue the heat until a heavier fluid begins to pass over, when the heat is to be lowered, and 1 lb. more spirit is then to be poured into the retort, and the distillation resumed. The products of these two distillations are then to be mixed together, and the supernatant liquid poured off; to this is now added 1 ounce of dried carbonate of potash, with occasional agitation, for an hour. Lastly, distil the ether from a larger retort, and preserve it in a well-stoppered bottle.

In preparing ether at the Apothecaries' Hall, a leaden still, with a pewter head, and connected by a tin pipe about 6 feet long with a powerful worm condenser, is employed. This is surrounded by a constant stream of ice-cold water. This, again, is connected with pewter receivers furnished with glass lids. The still is heated by a coil of lead pipe supplied with high-pressure steam, and the alcohol is supplied to the acid, as required, by means of a small pipe entering the upper part of the still.

Ether is an exceedingly inflammable and volatile spirit, possessing many important and useful attributes. While evaporating, it produces intense cold, a few drops poured upon the back of the hand, *at the same spot*, creating a sensation of painful coldness. Ether has frequently been employed in the preparation of artificial ice. One of the most important uses of ether is in the manufacture of "collodion" (a solution of pyroxylin in ether and alcohol); it is also employed as a solvent of indiarubber and some resins. Before the discovery of chloroform the vapour of ether was employed as an *anæsthetic*, from its power of producing insensibility to pain. Chloroform, however, has almost entirely superseded its employment for this purpose.

COLLODION.

This is a solution of pyroxylin, or soluble gun-cotton, in ether and alcohol. It may be prepared from various formulæ, from which the following has been selected as being the most simple : Take *sulphuric acid* and *strong nitric acid*, of each 10 fluid ounces; mix, and place in a porcelain capsule or ordinary teacup. Place the vessel on another vessel containing boiling water. Now take small tufts of cotton wool, well pulled out, and immerse them, one after another, stirring with a glass rod to effect perfect uniformity of action It is best not to immerse too large a quantity of cotton at one time, otherwise some parts of the fibre may be less protected from the action of the acid. The time of immersion required varies from ten to fifteen minutes. When the action is complete the pyroxylin is to be removed by means of the glass rod, and with it gently pressed against the sides of the vessel, it is then to be promptly thrown into a large quantity of cold water and well stirred. It is next to be placed in fresh cold water, and again well washed, the washing process to be repeated until all trace of acid is removed; this is readily ascertained by dipping a strip of blue litmus-paper in the water for a few minutes, when if the test-paper does not turn *red* the washing may be considered complete. The cotton is now to be wrung out in a clean linen cloth, and the fibres pulled out; it is then to be dried by *gentle heat.* Being more or less explosive, it is important that the cotton should not be dried too near a fire.

When dry, the pyroxylin may be preserved in a clean well-stoppered bottle, or dissolved for making *plain* collodion as follows : Shake up dry pyroxylin, 48 grains

with alcohol (specific gravity ·805) 1½ fluid ounce; then add ether 4½ ounces. After well shaking, to effect a perfect solution of the cotton, set aside for a week or ten days, when the clear liquor may be decanted from any sediment that may be present.

Iodized collodion, for photographic purposes, is made by dissolving *iodide of ammonium* 1½ drachm, *iodide of cadmium* 1½ drachm; or *bromide of ammonium* 40 grains, in alcohol 10 fluid ounces. To "iodize" the collodion add either of the above solutions to collodion in the proportion of 1 part iodizing solution to 3 parts collodion. The iodized collodion should not be used until several weeks after its preparation, but if required for immediate use, the addition of a few drops of an alcoholic solution of iodine may be added. This solution is made by dissolving 5 grains of iodine in 1 ounce of alcohol

PERFUMES.

These grateful and refreshing products of the garden and the still are solutions of essential oils (p. 179) in spirit of wine; and the various popular scents, as *Millefleurs, Eau de Cologne, Frangipanni*, etc., are formed by blending certain "essences" with each other in varied proportions, whereby an agreeable harmony of perfume, or *bouquet*, is obtained. For the last-named delightful perfume, as also for many others, the public are indebted to the exertions of Dr. Septimus Piesse. The importance of mixing the essential oils in due proportions, and only those which harmonize with each other, will be readily understood by those who are well acquainted with the culture of flowers and the proper arrangement of "nosegays" or *bouquets*. How many

a charming nosegay has been spoiled by the introduction, through carelessness or ignorance, of a sprig of feverfew, for instance, amidst roses and sweetbrier! Fancy a sprig of spearmint in a bunch of violets, or knotted marjoram blended with jasmine! Incompatibility of fragrance should be avoided not only in the operation of bunching flowers, but also in the process of blending their "essences" to produce what are called "perfumes."

Eau de Cologne is prepared by distilling or infusing the essential oils of rosemary, bergamot, lemon, neroli (oil of orange-flowers), jasmine, vanilla, benzoin, etc, in spirit of wine. Various proportions are employed to suit the public taste, but the following will give an idea of the general combination: Spirit of roses, 3 quarts; spirit of jasmine and spirit of wine, of each 3 pints; Portugal essence, 1½ ounce; flowers of benzoin (benzoic acid), 2 drachms; essence of vanilla and essence of musk, of each 6 ounces; orange-flower water, 3 pints. Or, spirit of wine, 9 quarts; balsam of Peru, 2 ounces; essence of bergamot, 4 ounces; essence of cloves, 2 ounces; essences of neroli and thyme, of each ½ ounce; essence of musk, 4 ounces; orange-flower water, 2 quarts.

Spirit of lavender may be prepared by taking Mitcham oil of lavender, 6 drachms; rectified spirit, 1 quart, and well agitating the mixture for a few minutes. This forms an agreeable and refreshing perfume.

Eau de bouquet.—Spirit of rosemary and essence of violets, of each 1 ounce; essential oils of bergamot and jasmine, of each 1 drachm; oils of verbena and lavender, of each ½ drachm; orange-flower water, 1 ounce; rose-water, ½ pint; rectified spirit, 6 quarts. Mix the whole together and shake well.

Rondeletia.—Oil of lavender (Mitcham), 3 ounces; oil of cloves, 1¼ ounce; oil of bergamot, 1 ounce; essences of musk and ambergris, of each 2 drachms; rectified spirit, 3 pints.

Eau de Millefleurs.—Musk, 12 grains; ambergris, 20 grains; essence of lemon, 1½ ounce; oils of lavender and cloves, of each 1 ounce; oil of verbena and neroli, of each ½ drachm; rectified spirit, 2 quarts Mix and macerate in a closely-covered vessel for at least ten days.

Essence of violets, so called, is in fact a tincture of *orris-root.* It is this root which also imparts the agreeable odour of violets to the "violet powder" of the shops. To make the essence, take Florentine orris-root in coarse powder, ½ lb; rectified spirit, 1 pint Macerate for fourteen days.

Extract of nosegay.—Benzoic acid, 1 drachm; essence of ambergris, 2 ounces; spirits of jasmine and violets, of each 1 pint; spirits of cassia, roses, orange-flowers, and gilly-flowers, of each ½ pint Mix and well agitate.

Esprit de la Reine.—Oil of bergamot, 1 ounce; essence of ambergris, 2 drachms; otto of roses, 1 drachm; rectified spirit, 1 quart.

Spirit of the flowers of Italy.—Spirits of roses, jasmine, cassia, and orange, of each 1 pint; orange-flower water, 1 pint. Mix and shake well.

Small quantities of perfume may be readily made by adding to a few ounces rectified spirit of wine a few drops of any of the essential oils, to which a few drops of neroli, or otto of rose, may be added with advantage.

PICTURE-RESTORING.

It is possible that the reader may think we are travelling beyond the line marked on the title-page of this

work in treating upon the present theme   We hope,
however, to justify our apparent departure by showing
that in skilful hands, and under proper treatment, the
restoration of old paintings may be rendered a "scientific
industry" rather than a mere rule-o'-thumb operation.
Indeed, when the value and importance of the works of
some of the old masters are taken into consideration, it
ought not to be in the hands of an ignorant tyro that such
priceless works of art should be trusted.

The late Mr. Elfred Blaker, whose name will be familiar
to many lovers of art and collectors of rare old paintings,
after many years of careful and successful manipulation,
devised a system for the restoration of old paintings which
gained for him a well-earned reputation amongst the best
judges of art in this country.   Being himself an artist
of much ability, well learned in the history of the old
masters, and thoroughly acquainted with the nature of
colours and varnishes, Mr. Blaker was in all respects
competent to undertake, as he frequently had to do, the
restoration of some of the rarest specimens of the old
schools.   We are indebted to a daughter of the late gifted
restorer for the following system which he successfully
practised during many years of his painstaking and in-
dustrious life.

The process of picture-restoring may be classified
under the following heads: 1. *Lining*; 2. *Stopping*;
3. *Cleaning*; 4. *Stippling*, or *restoring proper*.

1. Lining.—A strong wooden frame, called a "stretcher,"
is made of stout "quartering" of the size required, and
fitted with wedges (as in ordinary canvas "strainers"),
by means of which the frame may be slightly extended
so as to tighten or stretch a layer of canvas spread

over and secured to it by means of tacks. Take ordinary picture-liner's canvas, several inches wider each way than the picture to be lined, and tack it on to the frame.

The canvas being *strained* or *stretched* as above, the *back of the picture* is now to be carefully brushed over with a mixture composed of glue and "size," the *face of the canvas* being also brushed over with the same mixture. The picture is next to be laid *back downward* on the canvas, beginning at one corner and gently pressing it with the hand so as to disperse air-bubbles. The canvas is now to be tightened by driving in the wedges at each corner of the stretcher. Now take as many sheets of double-crown paper as will cover the entire picture (allowing each sheet to overlap the other about 1 inch); brush paste over one side of each sheet and fold separately. When the required number of sheets of paper have been thus prepared, take the first sheet, open it, and lay it carefully on the picture, beginning at one corner, and press it as before with the hand so as to remove air-bubbles. Each sheet is to be laid on in the same way until the entire picture is covered

After being left for a time, and when the paper is dry, the picture is subjected to pressure from a heavy heated iron, somewhat resembling a tailor's goose. For this purpose a perfectly smooth board, equal in thickness to the timber with which the stretching frame is made, is placed beneath the picture, at one corner, and the heated iron (the temperature of which must not be too high) is thus applied with steadiness and care, the pressing-board being shifted (when a large picture is under treatment) until the whole surface of the picture is well pressed. When the canvas

is perfectly dry, the paper is removed by a sponge and warm water.

When all traces of paper and paste are removed from the surface of the picture, the latter is next to be removed from the *rough* stretcher, the canvas neatly trimmed, leaving sufficient margin to attach it to a new strainer of a size suitable to the picture; the canvas margin is then to be tacked on to the edge of the frame in the usual way, after which the wedges are to be driven tight.

2. **Stopping.**—The object of this operation is to fill all fissures or cracks in the picture with a composition which is capable of receiving a coating of paint without absorbing it. The composition employed for this purpose consists of a mixture of size and whiting, to which a small quantity of black is added to give the composition a neutral tint. The "stopping," as this mixture is called, is pressed into the cracks by means of a palette-knife, care being taken that every fissure is well filled with it. The picture must now be set aside for several days to allow the stopping to become gradually but thoroughly dry. The next operation is to remove the superfluous stopping, which is effected by rubbing the surface of the picture with a soft or "velvet" cork moistened with water. The cork must be applied gently and with a circular motion, so that, while removing the superfluity, the cracks may be left perfectly level.

3. **Cleaning.**—This term is applied technically to the removal of varnish from old pictures, and it is scarcely necessary to say that if this were attempted by means of chemical solvents of gum resins, which form the basis of most varnishes, old or new, the operation would be very hazardous in skilful hands, while in those of an ignoramus

the underlying picture would (as has frequently been the case) be sacrificed, by the solvent, as turpentine, for example, after attacking the varnish, performing the function of dissolving the oil of the picture This barbarous application of varnish solvents has acquired the appropriate name of "skinning," a term which implies the removal not only of the varnish, but the picture itself!

Although it is possible by means of chemical solvents to remove coats of varnish from the surface of oil paintings, the plan adopted by Mr. Blaker is by far the most safe, and in practical hands the most secure. It consists in rubbing the varnished surface gently with the finger, by which the resinous matter works up into a powdery condition, and this action is kept up with great care until the colours of the picture, as will be readily understood, become exposed to view.

4. Restoring.—When it is borne in mind that the varied tints and colours employed by the old masters (and many of which are of doubtful origin at the present day) require to be faithfully matched, it will be understood that only an artist of great skill and experience, possessing an extensive knowledge of the productions of the old painters, should be intrusted with the delicate operation of renovating, without spoiling, works of olden time.

The process called "stippling" is adopted for matching the various colours and tints, very small brushes being employed, and each brush being reserved for its special use with great care, in order to avoid even the most trifling risk of mismatching any required tint.

When the stippling has thus been done by an artist possessing knowledge and experience, as well as natural ability (the two first-named attributes being the most

essential), the picture, when "restored," and subsequently varnished, presents the appearance of a *perfect* picture, the touches of the restorer being imperceptible.

Before the picture is varnished, strips of white paper about 1½ inch in width are neatly pasted round the edge of the frame, and overlapping the picture about one-eighth of an inch, so as to leave a neat but scarcely perceptible margin.

The *varnishing* of oil paintings is more properly effected by skill than by rule o' thumb. The operation should be conducted in a *warm room*, perfectly free from dust. The picture should be laid flat on a level bench, and a small quantity of varnish poured on its centre; a flat soft brush is then taken, and with this the varnish is brushed over the surface, care being taken to avoid "brush-marks" The picture is then allowed to remain in its horizontal position until the varnish is thoroughly dry.

SULPHATE OF QUININE.

This important and valuable medicine is obtained from *yellow cinchona bark*. The process generally adopted by manufacturers is as follows: Coarsely-bruised yellow bark is boiled with water acidulated with either sulphuric or hydrochloric acid. After the clear liquor is decanted, the residue is again boiled with acid and water a second, a third, or even a fourth time The various decoctions thus obtained are then mixed and filtered, and when cool, finely-powdered slaked lime is added until the liquid becomes alkaline and of a dark colour. The precipitate which forms is collected, drained, and submitted to pressure. The cake which results is dried, then powdered, and afterwards

digested in rectified spirit. The tincture thus obtained is now filtered and subjected to distillation, when impure quinine remains in the retort in the form of a brown viscid substance. This is next saturated with very dilute sulphuric acid; the solution is again filtered, and afterwards set aside to crystallize. The yellowish crystals of *disulphate of quinine* thus obtained are next drained in a cloth, pressed, again dissolved in water, and decolorized by adding animal charcoal. The solution is then evaporated and set aside to recrystallize. The crystals, after being well drained, are dried with great care. Although there are several methods of preparing this interesting substance, the process given above may be considered one of the best.

The disulphate (or sulphate, as it is commonly called) of quinine is considered one of the most important tonics known in pharmacy, while as a febrifuge it has the highest reputation. In restoring energy to weakened constitutions, and in allaying neuralgic and other nervous pains, it has no equal in medicine.

PARAFFINE OIL.

This useful oil, now so generally employed for burning in table-lamps, is obtained, under Mr. Young's patent, by the distillation of Boghead coal, cannel coal, etc., at a lower temperature than is required to produce ordinary coal-gas for illuminating purposes.

The coal (Boghead) is first broken into small pieces, and is then placed in perpendicular retorts about 11 feet in height. The coal is introduced into the retorts by means of conical "hoppers" at their upper extremities. A set of four such retorts is built into one large furnace, the lower

ends of which are closed by dipping into shallow pools of water. When the coal passes through the hottest part of the retorts, its volatile constituents become liberated, and these are conducted by iron tubes to condensers. The non-volatile matters are raked out from the lower ends of the retorts, while a continued supply of fresh coal is kept up by charging the retorts through the hoppers, as before.

The *crude oil*, which first passes over into the condensers, is a thick dark-coloured liquid; this is afterwards distilled to dryness in large iron stills, by which the excess of carbon is retained in the still in the form of coke. The oil is afterwards treated with strong sulphuric acid, which has the effect of charring its principal impurities, which subside, with the acid, in the form of a dense black tar. Caustic soda is next added to remove further impurities.

The oil is next subjected to distillation at various temperatures, by which four different products are obtained. The first product which passes over at the *lowest* temperature is called *paraffine naphtha*, which is employed as a cheap substitute for oil of turpentine for dissolving indiarubber; it is this substance which "Cheap Jacks" and costermongers employ in their lamps

An important feature in "Young's paraffine oil," when carefully prepared and the naphtha entirely removed by distillation, is its safety as a burning oil. The paraffine oil of commerce should not ignite when brought near the flame of a candle, but if even a small quantity of naphtha be present in the oil, it will inflame immediately. When this is the case, the oil should not be used for burning in a lamp, for this reason: when the receptacle in which the oil is placed becomes warm, the volatile spirit (naphtha) vaporizes, and will readily take fire, probably with explosion and consequent mischief

After the naphtha and paraffine oil have been distilled over, a third product is obtained at a higher temperature; this is used as a *machinery* or *lubricating* oil A fourth, and last, product is next obtained by treating this last oil by means of artificial cold, by which a solid translucent substance resembling spermaceti is obtained This is the beautiful paraffine so much used in making candles (see p. 16).

SULPHATE OF COPPER.

Under the familiar names of *blue-vitriol, blue-stone,* etc., this beautiful salt of copper performs many important functions in the arts; and indeed it is to this we are indebted for the discovery of the art of electrotyping, and, indirectly, all the processes of electro-deposition which followed its discovery and practical application.

Commercial sulphate of copper is prepared from copper pyrites, or native sulphuret of copper. The ore is first *roasted* and then moistened with water, after which it is exposed to the air for a considerable time, by which means the copper becomes converted into *oxide of copper,* and the sulphur into *sulphuric acid,* the result being the formation of *sulphate of copper.* This salt is then dissolved out, and the solution evaporated and afterwards set aside to crystallize.

In some copper mines the water passing through them is strongly impregnated with sulphate of copper, and this is collected, evaporated, and crystallized for commercial use. Sulphate of copper is also obtained as a product resulting from the refining of silver. By dissolving oxide or carbonate of copper in sulphuric acid, *pure* sulphate of copper is obtained.

ALLOYS OF METALS.

The alloying of metals with each other is of very ancient date, and many of the alloys have to a great extent supplanted the use of pure metal It is not alone from a desire to adulterate or cheapen a richer metal by adding to it one of inferior value that the art of alloying consists, for in some instances the alloy is of greater commercial value as to its uses than the separate metals from which it is compounded.

Some of the most familiar alloys are given below.

		ARE ALLOYS OF .
Albata, Argentane, German silver, or Nickel silver		Nickel, copper, and zinc (with sometimes iron).
Bath-metal		Copper and zinc.
Bell-metal		Copper and tin.
Brass		Copper and zinc.
Britannia metal		Tin, antimony, copper, and bismuth.
Bronze		Tin and copper.
Dutch gold		Copper and zinc.
Gun-metal		Tin and copper.
Mosaic gold, Ormolu		Copper and zinc.
Pewter		Tin and lead (with sometimes antimony and bismuth).
Queen's metal		Tin, antimony, bismuth, and copper.
Shot-metal		Lead with a little arsenic.
Silver (standard)		Silver and copper.
Solder		Tin and lead.
Stereotype-metal		Lead, antimony, and bismuth.
Type-metal		Lead and antimony.
White copper		Copper and arsenic.

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